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RESEARCH MEMORANDUM

TIME-HISTORY DATA OF MANEUVERS

PERFORMED BY A LOCKHEED F-94B AIRPLANE

DURING SQUADRON OPERATIONAL TRAINING

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Langley Field, Va.

CLASSIFIED DOCUMENT

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TIME-HISTORY DATA OF MANEUVERS

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SUMMARY

Preliminary results of one phase of a control-motion study program involving several jet fighter-type airplanes are presented in time-history form and are summarized as maximum measured quantities plotted against indicated airspeed. The results were obtained from approximately 350 maneuvers performed by a Lockheed F-94B jet interceptor airplane during squadron operational training. Most of the tactical maneuvers that are within the capabilities of the F-94B airplane are included in the data. The maneuvers were performed at pressure altitudes of 0 to 32,000 feet and at indicated airspeeds ranging from the stall to approximately 500 knots.

INTRODUCTION

The present method of determining airplane design loads requires, among other things, a knowledge of the motion of the control surfaces. In the usual methods, the maximum design loads are obtained by specifying what are believed to be the critical motions of the control surfaces and subsequent airplane responses; however, the actual control motion and load-factor variations obtained in regular operational flying may differ appreciably from the specified variations, even though the specified control rates do not exceed the limits of the pilot or airplane.

In order to obtain information on the actual control motions used in flight, the National Advisory Committee for Aeronautics in cooperation with the U. S. Air Force and the Bureau of Aeronautics, Department of the Navy, is conducting a control-motion study program. This program is directed toward obtaining sample measurements on several jet fighter-type airplanes of rates, amounts, and combinations of control motions

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used by service pilots in carrying out operational training missions. From tests of this kind, it may be possible to determine more realistic design load criteria and also information useful in the design of airplane control-boost systems. References 1 to 4 are other papers which originated from this program.

The present paper includes data in time-history form of maneuvers performed by a Lockheed F-94B airplane during regularly scheduled operational training missions. In order to expedite the presentation of these data, only a minor analysis of the results is included to present maximum values. The time histories have been reduced to page size to facilitate the reproduction and distribution of the large amount of material. These figures are considered adequate for minor analyses of the data, such as determining maximum values. If extensive analysis of the included data is desired, copies of the time histories, approximately $2\frac{1}{2}$ times larger, are available on request to the NACA.

TEST AIRPLANE

The airplane used in this program was a standard Air Force F-94B-1-10 airplane, serial number 51-5380A. This airplane is a two-place, straight low-wing, all-weather interceptor powered by a single Allison turbojet engine equipped with afterburner. The aileron control forces are augmented by a hydraulic booster mechanism. Hydraulically operated speed brakes are incorporated in the bottom of the fuselage.

The external appearance and the weight and balance of the airplane were altered as little as possible by the addition of the instrumentation. A photograph of the F-94B test airplane is presented as figure 1 and a three-view drawing is presented in figure 2. Physical characteristics and dimensions are given in table I.

INSTRUMENTS

Standard NACA photographically recording instruments were used to measure and record (1) the quantities defining flight conditions - that is, airspeed, altitude, and speed-brake position; (2) the imposed control motions; and (3) the response of the airplane in terms of angular velocities and accelerations, load factors, airplane sideslip angle, and airplane angle of attack. The recorders were synchronized at 1-second intervals by means of a common timing circuit. All recorders were

mounted in the nose armament section with the exception of the single- and three-component accelerometers which were mounted in the forward part of the engine section.

In order to relieve the pilot of any recording-instrument switching procedure and thus enable normal operation, a pressure switch was used to turn on the recording instrument automatically at an indicated air-speed of approximately 95 knots. Also, a nose-wheel-door microswitch, which was actuated when the door closed, was employed to keep the recording instruments turned on should the indicated airspeed go below 95 knots.

A standard two-cell pressure recorder connected to the airplane service system was used to measure the pressure altitude and indicated airspeed. The service system employs a total-pressure tube attached to the bottom of the fuselage below the nose armament section and flush static-pressure orifices on either side of the lower fuselage forward of the armament section. (See figs. 1 and 2.)

A microswitch was used on the right speed brake to indicate the open or closed position of this surface. The control-surface deflections were measured by a control-position recorder having remote recording electrical transmitters installed at the control surfaces. The elevator and rudder transmitters were installed inside the tail fairings in order to take measurements at the inner hinge. The aileron transmitter was located internally at approximately the right-aileron midspan.

Angular velocities and accelerations were recorded about three mutually perpendicular axes of which the longitudinal axis is the one commonly used for leveling the airplane. (See fig. 2.)

Normal load factors were measured by a single-component accelerometer located 2.81 feet aft and 0.99 foot below the average flight center-of-gravity location of 26.64 percent of the wing mean aerodynamic chord. Longitudinal and transverse load factors were measured by a three-component accelerometer (of which only two components were used) located 2.81 feet aft, 0.99 foot below, and 1.25 feet to the right of the average flight center-of-gravity location.

The airplane sideslip angle and airplane angle of attack were measured by flow-direction recorders mounted on a boom extending from the upper left gun port. (See fig. 2.)

A summary of the quantities measured, instruments used, accuracies of the measurements, and the natural frequencies of the instruments is given in table II. As will be noted, the accuracy of each measured quantity is divided into two parts; instrument accuracy, which is estimated with regard to errors introduced by the instrument characteristics,

and the reproduction error, which is based on inherent errors resulting from preparing and reproducing the time histories. The addition of these two accuracies will give the total possible error with respect to the true zero. Incremental values would, of course, be associated only with the instrument accuracy.

All the recording instruments were damped to about 0.65 of critical damping. The natural frequency of the elements in all the instruments was selected to give the best compromise value which would minimize the magnitudes of extraneous airplane vibrations and still give correct response to the maneuver-imposed deflections.

TESTS

The tests consisted of eighteen squadron operational training flights carried out during February and March, 1952. The maneuvers obtained were flown at pressure altitudes of 0 to 32,000 feet and at indicated airspeeds varying from the stall to approximately 500 knots and include most of the tactical maneuvers that are within the capabilities of the F-94B airplane.

With the exception of one flight, the test airplane was flown with no wing-tip tanks, since this condition more nearly resembles the combat configuration of the airplane. Several flights were also made without the radar observer.

Enough film was carried during each flight to allow approximately 80 minutes of flight time to be recorded. This was usually sufficient time to record the complete flight. In this program 7.9 hours of flight time were recorded, of which 3.9 hours are presented in this paper as maneuvers in time-history form. The ratio of flight time to maneuver time of approximately 2 is not necessarily representative of normal operation because the pilots were requested to perform as many maneuvers as practical during each flight in order to minimize the time required to collect the data.

Eight pilots participated in these tests. No pilot accounted for more than 20 percent of the maneuver time. Anti-gravity suits were sometimes worn by the pilots during these tests.

In order to obtain records which would contain representative samples of normal piloting technique in the performance of the maneuvers, the pilots were assured that the instrumentation would not restrict them in any way as to type of maneuver, manner of control manipulation, or severity of maneuvering. Also, they were assured that they would not be identified with the results.

METHOD AND RESULTS

In order to expedite the transition of the flight data to time-history form, a photographic method of preparing time histories was developed. Briefly, this method consisted of three main steps: (1) direct reproduction of the flight film records; (2) assembling of the records for each particular maneuver; and (3) photographing the assembled records through a master-grid overlay. The same care in adjusting the instruments to preselected sensitivities and selecting the film drums was necessary for this method as was exercised for the methods used in references 2 and 3. It is believed that the use of the present method has resulted in more rapid reproduction of the data and in maintaining a high over-all accuracy and greater preservation of many of the film-record details.

The master-grid overlay was constructed to conform to the various instrument sensitivities, calibrations, and film drum speeds. Because of this, some of the quantities have nonlinear grids and the dimensions of the linear grids vary slightly for each quantity measured.

The basic results obtained from this flight program are presented in figures 3 to 303 as time histories of the measured quantities for each maneuver and are summarized as maximum measured quantities plotted against indicated airspeed in figures 304 to 312. The time histories are arranged in this paper according to maneuver classification as given in table III. Included in the legend of these figures is a description of the type of maneuver and estimated in-flight airplane weight and center-of-gravity location. As a matter of interest, the legend also states which pilot (pilot A, B, C, D, E, F, G, or H) performed the maneuver, whether the pilot wore an anti-gravity suit, whether the maneuver was performed with a radar observer aboard, and whether wing-tip tanks were on. Describing the maneuvers was, of necessity, done in a general sense because it was sometimes difficult to determine from the flight records exactly the type of maneuver performed. Most of the standard maneuvers are interpreted in references 5 and 6. The in-flight airplane weight and center-of-gravity location were estimated on the basis of the total amount of fuel used and the total time the engine was running, taking into account fuel used for warm-up, taxiing, and afterburner operation during take-off.

In these time histories, the airspeed is indicated airspeed, defined as the reading of a differential-pressure airspeed indicator, calibrated in accordance with the accepted standard adiabatic formula to indicate true airspeed for standard sea-level conditions only (uncorrected for instrument and installation errors). The altitude is the NACA standard pressure altitude.

The control-position curves shown were measured with respect to their neutral position. Only the right-aileron deflection was measured. The open position of the speed brakes is indicated on the time histories by the dashed line and the words "brakes open."

In these figures load factors associated with forces acting up, forward, and to the right are positive. Nose up, nose right, and right wing down are positive for the pitching, yawing, and rolling angular velocities and angular accelerations which are given in radians per second and radians per second per second, respectively. No angular-velocity or angular-acceleration corrections to the recorded load factors due to the displacement of the accelerometers from the center of gravity have been made in these time histories. It should be noted that on several of the time histories, the angular acceleration records are missing, either in whole or in part. In these cases, usually at the higher Mach numbers, airplane structural vibrations caused the angular-acceleration record to vibrate at a high frequency and amplitude, so that the record was unreliable and of poor quality for reproduction. It will also be noted that portions of the acceleration records have been faired in with a dashed line. This was done whenever it was believed that the record was reliable but of poor reproductive quality. This dashed-line fairing, coupled with the hashiness of the angular-acceleration records, makes it possible to distinguish between the angular-acceleration and angular-velocity traces.

The angle of sideslip shown in the time histories is the angle between the longitudinal axis and the projection of the relative wind in the horizontal plane of the airplane and is positive for a nose-right attitude. The angle of attack is the angle between the longitudinal axis and the projection of the relative wind in the vertical plane of the airplane and is positive for a nose-up attitude. In several figures it was necessary to fair the angle-of-sideslip and angle-of-attack records with a dashed line because excessive vibrations, ordinarily incurred during take-offs, stalls, and landings, made them of poor reproductive quality. The angle-of-sideslip and angle-of-attack values in the figures are uncorrected for angular-velocity, sidewash, and upwash effects. It is estimated that the sidewash and upwash effects would increase the measured angle of sideslip and angle of attack by approximately 5 percent and 10 percent, respectively.

A comparison between the normal load factors obtained in these tests and an operational V-n diagram is presented in figure 304. The V-n envelopes shown in this figure are the operational limitations for the test airplane at a gross weight of 12,238 pounds which is the average flight weight for the maneuvers presented in this paper. The normal load factors in figure 304 were taken directly from the time histories and are plotted without angular-velocity or angular-acceleration corrections since such corrections were found to be small.

The maximum transverse load factors and corresponding indicated airspeeds are presented in figure 305. Because of the large number of small transverse load factors available from the time histories, only the values above the arbitrary limit of 0.05 are presented. All the transverse load factors given in figure 305 have been corrected for the effects of rolling and yawing angular velocity and angular acceleration.

The maximum control rates and their variation with indicated airspeed are shown in figures 306, 308, and 310. These maximum values were obtained from the maximum slope of the appropriate control-position record. In these figures the measurements obtained from the time histories in the region of main-gear take-off or touchdown are distinguished from the completely airborne measurements by a different symbol.

The maximum pitching-, rolling-, and yawing-angular-acceleration variations with indicated airspeed are shown in figures 307, 309, and 311, respectively. Where the angular acceleration records were missing in the time histories, the maximum angular accelerations were obtained from the maximum slope of the appropriate angular-velocity record. Only the maximum angular-acceleration values above the arbitrary limit of 0.1 radian per second per second for pitch and yaw and 0.5 radian per second per second for roll are included in these figures as being significant.

The variation of maximum angles of sideslip with indicated airspeed is shown in figure 312. These angles, which were taken from the time histories, have not been corrected for sidewash effects.

No corrections have been made to the indicated airspeed for position error in any of the summary figures (figs. 304 to 312). Also, only the maximum values deemed necessary to demonstrate the trends are presented in these figures. The measurements obtained during a stall are indicated in figures 307, 309, 311, and 312 by a different symbol only at low indicated airspeeds, since the envelopes at the higher speeds were not materially affected by stalls. Directional-oscillation effects are also distinguished in figures 305, 311, and 312 by a different symbol.

DISCUSSION

The data of this investigation include most of the tactical maneuvers within the capabilities of the F-94B airplane and, although limited to a few hours of actual flying time, represent a cross section of the maneuvers performed during operational training.

Examination of figure 304 indicates that during these tests the operational limits of the V-n diagram were approached for many combinations of load factor, airspeed, and altitude. It is also evident that the positive normal-load-factor region of the V-n diagram was utilized to a much greater degree than was the negative load-factor region.

The region of the V-n diagram limited by the maximum lift coefficient was, as would be expected, approached in many of the maneuvers, especially in turns and stalls. (See figs. 31, 47, 48, 237, 240, and 242.) The limit positive normal load factor, 7.33, was approached in turns and in pull-ups or pull-outs during such maneuvers as roll entries into dives, chandelles, Immelmans, and vertical recoveries (see figs. 28, 38, 72, 77, 181, 216, 237, 250, and 273). The highest positive normal load factor recorded, 7.4, was obtained at an airplane weight of 11,760 pounds and an indicated airspeed of 375 knots during a right turn. (See fig. 23.) The high-speed, high-positive-load-factor region of the V-n diagram was not closely approached.

Negative load factors were rarely obtained. The greatest negative normal load factor, -0.5, was obtained at 275 knots during a right-aileron roll. (See fig. 81.) This trend in negative load factor may be influenced by the engine characteristics since engine operation cannot be maintained for an extended period of time in the negative-load-factor region. Normal load factors less than 1 were usually associated with turns, rolls, and stalls. (See figs. 50, 51, 52, 72, 86, 107, 117, 235, 236, and 241.)

The maximum corrected transverse load factors, 0.38, at 355 knots and -0.37 at 300 knots, shown in figure 305, were obtained in an abrupt left turn and in a right aileron roll, respectively. (See fig. 38 at time 7.5 seconds and fig. 264 at time 14.5 seconds.) The largest measured values of transverse load factor were usually experienced in rolling maneuvers such as turns, rolls, roll entries into dives, wing-overs, chandelles, Immelmans, and vertical recoveries and also in rudder kicks. (See figs. 39, 47, 83, 118, 147, 216, 251, 252, 261, 279, and 233.) Examination of figure 305 indicates that the value of corrected transverse load factor experienced in these tests was usually between ± 0.30 .

Longitudinal load factors of 0.4 to 0.6 were obtained in such maneuvers as turns, rolls, roll entries into dives, wing-overs, loops, Immelmans, stalls and vertical recoveries. (See figs. 23, 66, 92, 118, 133, 168, 210, 212, 216, 242, 250, and 278.) Landings, use of the afterburner, and extension of the speed brakes also had pronounced effects on the longitudinal load factor. Larger longitudinal load factors were obtained during landings at the time of main-gear touchdown and during the following braking period. Use of the afterburner

caused an acceleration equivalent to about 0.2 load factor at 440 to 470 knots. (See fig. 216 at time 30 seconds, fig. 218 at time 20 seconds and fig. 251 at time 43.5 seconds.) Extension of the speed brakes caused a deceleration equivalent to approximately -0.4 load factor at 385 knots and 1,400 feet altitude. (See fig. 38.) The speed-brake effect is also shown in figures 68, 118, 200, and 287.

In general, the elevator rates, as shown in figure 306, were greatest at low speeds and decreased with increasing indicated airspeed. The highest positive elevator rate obtained in these tests was 5 radians per second and occurred during a landing. (See fig. 301 at time 40.5 seconds.) The largest negative elevator rate, -2.23 radians per second, also occurred during a landing. (See fig. 292 at time 39.5 seconds.) Examination of the take-off and landing time histories reveals that in most cases the greater elevator rates were used in landing. The other maximum elevator rates were obtained in maneuvers necessitating a pull-up, such as turns, roll entries or recoveries, roll entries into dives, chandelles, pull-ups, loops, split-S's, and stalls. (See figs. 48, 119, 152, 180, 199, 206, 225, 235, 241, and 255.)

The negative pitching accelerations obtained in these tests were, in general, larger than the positive values. (See fig. 307.) The greatest negative pitching acceleration, -1.3 radians per second per second at 185 knots, occurred during a split-S (fig. 225 at time 18.5 seconds) while the greatest positive pitching acceleration, 0.75 radian per second per second at 340 knots, resulted from a pull-up during a lazy eight. (See fig. 255 at time 30.5 seconds.) Pitching accelerations greater than 10.70 radian per second per second were obtained in such maneuvers as turns, wing-overs, chandelles, and stalls. (See figs. 38, 168, 180, 237, and 242.)

Pitching velocities never exceeded 0.5 radian per second and were usually less than 0.4 radian per second. The larger pitching velocities occurred in turns, rolls, loops, Immelmans, split-S's, and stalls as shown in figures 38, 39, 129, 131, 210, 211, 225, 236, 237, and 241.

Examination of figure 308 indicates that in general the aileron rates used during this program increased with increasing airspeed to a value of about 11.0 radian per second at 250 knots and then decreased with increasing airspeed. However, this figure also shows that values as high as 1.34 radians per second were obtained at high indicated airspeeds. This aileron rate was obtained in an abrupt right turn at an indicated airspeed of 440 knots. (See fig. 28.) As would be expected, large aileron rates were recorded in rolling maneuvers such as turns, rolls, Immelmans, and vertical recoveries, and on occasion, during stalls. (See figs. 37, 40, 47, 78, 92, 102, 114, 213, 269, 279, 254, and 257.)

Rolling accelerations of approximately ± 5 radians per second per second were obtained in these tests at an indicated airspeed of about 370 knots and, in general, decreased above and below this airspeed. (See fig. 309.) However, a rolling acceleration of 6.75 radians per second per second was obtained at 440 knots. This high value occurred during an abrupt right turn (fig. 28) and is associated with the high aileron rate shown in figure 308. Other high rolling accelerations were obtained in turns and rolls as shown in figures 42, 47, 114, 260, 298, and 303.

The maximum measured rolling velocities, 2.2 radians per second at 275 knots and 17,700 feet altitude and -2.3 radians per second at 300 knots and 17,000 feet altitude, occurred during aileron rolls. (See figs. 113 and 128.) Other high rolling velocities occurred in aileron rolls as shown in figures 91, 96, 132, and 260.

The maximum rudder rates used in take-off and landing were approximately 2.5 times greater than the maximum rudder rates used during the other maneuvers. (See fig. 310.) The maximum rudder rates of ± 2.8 radians per second at 100 knots occurred during take-off. (See fig. 7 at time 4.0 seconds and fig. 8 at time 0.5 second.) Comparison of the take-off and landing time histories indicates that during this program the rudder rates were higher during take-off than in landing, although the rudder was used more during landings. The rudder rates used in other maneuvers decreased from 0.93 and -0.66 radian per second at 180 knots to practically 0 at 400 knots. The highest rudder rates were measured in such maneuvers as turns, rolls, Immelmans, sideslips, and rudder kicks. (See figs. 42, 97, 114, 213, 231, and 233.) However, examination of the time histories indicates that, with the exception of take-off and landing, the rudder was not used to any great extent during these tests.

The maximum yawing accelerations, as shown in figure 311, due to maneuvering, were -0.62 radian per second per second at 355 knots and 0.60 radian per second per second at 225 knots and occurred during a left turn and rudder kick, respectively. (See figs. 38 and 233.) Other high yawing accelerations were obtained in turns, rolls, and vertical recoveries. (See figs. 39, 48, 72, 113, 264, and 280.)

The yawing velocities obtained during these tests did not exceed ± 0.30 radian per second. High yawing velocities of the order of ± 0.20 to ± 0.28 radian per second were obtained in such maneuvers as turns, rolls, roll entries into dives, split-S's, sideslips, rudder kicks, stalls, and vertical recoveries. (See figs. 38, 47, 91, 107, 113, 152, 228, 231, 233, 241, 245, 262, and 278.)

The largest angles of sideslip occurred at the lower airspeeds and decreased with increasing airspeeds. (See fig. 312.) The highest sideslip angle obtained in these tests, -11.1° at 225 knots, occurred in an

abrupt left turn. (See fig. 47.) Other large sideslip angles were obtained in turns, rolls, Immelmans, sideslips, and rudder kicks. (See figs. 48, 83, 132, 212, 213, 231, 232, 233, and 261.)

Thus far, the discussion has been concerned with the response of the airplane to pilot-imposed control motions. It is also of interest, therefore, to point out the response of the airplane to excitations not imposed by the pilot, such as rough air, isolated gusts, and the tendency of the airplane to oscillate directionally at the higher Mach numbers.

The effects of rough air can be seen in figures 45, 144, 181, 292, and 299 and the effects of isolated gusts are shown in figures 180, 205, 255, and 273. These figures show, as would be expected, that rough air and gusts cause rapid changes, varying in magnitude, in the load factors and angular accelerations with corresponding changes in the angles of attack and sideslip. The most severe isolated gust encountered is shown in figure 255. This figure indicates that a down gust was encountered which caused the pilot to react in such a manner as to subject the airplane to its limit normal load factor, 7.33. This gust also caused high yawing and rolling accelerations of the order of -1.0 and -5.5 radians per second per second, respectively.

The effects of directional oscillations are especially pronounced at the higher Mach numbers and are particularly evident in the transverse load factor, yawing acceleration, and sideslip angle. (See figs. 130, 166, 182, 192, 193, 216, 221, 280, and 286.) The magnitudes of these effects are shown in summary figures 305, 311, and 312.

From the figures presented, it may be noted that none of the types of maneuvers obtained during these tests imposed maximum loads on all major components of the airplane at the same time. Probably the most severe maneuvers obtained in this respect were the uncoordinated, high-speed, abrupt turns, such as those shown in figures 38 and 47. This type of turn subjected the test airplane to high angular velocities and accelerations, large normal and transverse load factors, and large angles of attack and sideslip.

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TABLE I
DIMENSIONS AND PHYSICAL CHARACTERISTICS
OF THE F-94B TEST AIRPLANE

Wing:

Total area with tip tanks off (including flaps, ailerons, and 40.8 sq ft covered by fuselage) sq ft	238.0
Span (horizontal without tip tanks), in.	451.50
Aspect ratio	5.96
Taper ratio (Tip chord/Root chord)	0.38
Root chord, in.	109.98
Mean aerodynamic chord (at wing station 92 measured normal to airplane center line), in.	80.60
Sweepback (leading edge), deg	9.31
Root airfoil section	NACA 65 ₁₁₂ -213
Tip airfoil section	NACA 65 ₁₁₂ -213
Incidence at root, deg	1.00
Incidence at tip, deg	-0.50
Dihedral (at trailing edge of wing reference plane), deg	3.83
Aileron area (one, including tab), sq ft	8.75
Aileron span (leading edge), in.	89.86
Aileron root chord, in.	17.47
Aileron tip chord, in.	10.60
Aileron static control limits, deg	±20.00
Distance from nose to leading edge of wing M.A.C., in.	210.90
Distance of wing mean aerodynamic chord below fuselage reference line, in.	13.38

Horizontal tail:

Total area (including elevator with tabs), sq ft	47.83
Span, in.	199.00
Aspect ratio	5.75
Taper ratio (Tip chord/Root chord)	0.36
Root chord, in.	52.00
Mean aerodynamic chord (horizontal tail station 38.5 measured normal to airplane center line), in.	38.20
Airfoil section	NACA 65-010
Incidence, deg	0.50
Dihedral, deg	0
Elevator area (two, including tabs), sq ft	8.70
Elevator span (leading edge, one), in.	74.88
Elevator root chord, in.	13.00
Elevator tip chord (excluding aerodynamic balance), in.	4.75

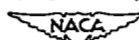


TABLE I.- Continued

DIMENSIONS AND PHYSICAL CHARACTERISTICS
OF THE F-94B TEST AIRPLANE

Elevator static control limits (from neutral position), deg	
Up	38.00
Down	17.50
Distance from leading edge of wing mean aerodynamic chord to 25 percent mean aerodynamic chord of horizontal tail, in.	210.60
Distance of horizontal-tail mean aerodynamic chord above fuselage reference line, in.	28.38
Vertical tail:	
Total area (excluding dorsal fin), sq ft	22.50
Span (from bottom of rudder), in.	77.00
Aspect ratio	1.83
Taper ratio (Tip chord/Root chord)	0.40
Root chord, in.	65.00
Tip chord, in.	26.00
Mean aerodynamic chord (parallel to and 28.50 inches above vertical-tail root chord), in.	48.25
Airfoil section	NACA 65-010
Rudder area, sq ft	5.30
Rudder span (leading edge), in.	66.25
Rudder root chord, in.	16.25
Rudder tip chord (excluding aerodynamic balance), in.	6.50
Rudder static control limits, deg	±30.00
Distance from leading edge of wing aerodynamic chord to 25 percent mean aerodynamic chord of vertical tail, in.	213.60
Distance of vertical-tail mean aerodynamic chord parallel to and above fuselage reference line, in.	57.78
Fuselage:	
Total length (excluding nose boom), in.	481.30
Maximum width, in.	56.00
Maximum depth (excluding canopy), in.	56.00
Effective speed-brake plan area (two), sq ft	5.80
Speed-brake length (one), in.	26.60
Speed-brake width (one), in.	16.00
Speed-brake open position, deg down	60.00
Speed-brake maximum opening time, sec	2.2
Speed-brake maximum closing time, sec	1.9


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TABLE I.- Continued
 DIMENSIONS AND PHYSICAL CHARACTERISTICS
 OF THE F-94B TEST AIRPLANE

Tip tanks:

Length, in.	181.0
Maximum diameter, in.	25.6
Weight (one empty), lb	190.0
Capacity (one), U. S. gal	230.0
Distance from tip-tank nose to 52 percent of wing-chord line, in.	91.5
Fin area (including 1.4 sq ft covered by tip tank), sq ft	4.1
Fin span (measured from tip-tank center line), in.	28.0
Fin root chord (measured along tip-tank center line), in.	29.0
Fin tip chord (measured parallel to tip-tank center line), in.	13.0
Distance from tip-tank nose to trailing edge of fin, in.	169.5

Power plant (one) Allison J-33-A-33 equipped with afterburner

Airplane weights and center-of-gravity positions:

- (1) Measured airplane weight (includes two 50-caliber machine guns without ammunition; instruments; 230 lb pilot; 200 lb ballast in nose; no wing tip tanks; and all other tanks full service), lb 13,157
- (2) Measured airplane center-of-gravity position corresponding to the airplane weight of 13,157 lb and with gear up or down, percent wing mean aerodynamic chord 27.51
- (3) Calculated center-of-gravity position corresponding to the airplane weight of 13,387 lb (includes same items as (1) with addition of 230 lb radar observer), percent wing mean aerodynamic chord 26.68
- (4) Calculated center-of-gravity position corresponding to the airplane weight of 13,537 lb (includes same items as (1) with addition of two 190-lb wing tip tanks) percent wing mean aerodynamic chord 27.94
- (5) Calculated center-of-gravity position corresponding to the airplane weight of 16,527 lb (includes same items as (1) with addition of two 190-lb wing tip tanks containing 2990 lb of fuel), percent wing mean aerodynamic chord 29.28

TABLE I.- Concluded
DIMENSIONS AND PHYSICAL CHARACTERISTICS
OF THE F-94B TEST AIRPLANE

Moments of inertia:

Airplane gross weight of 13,649 lb which includes radar
operator but not wing tip tanks, slug-ft²

I_x (roll)	11,949
I_y (pitch)	26,635
I_z (yaw)	37,779

Airplane gross weight of 17,019 lb which includes radar
operator, tip tanks on and fully serviced, slug-ft²

I_x (roll)	51,424
I_y (pitch)	27,155
I_z (yaw)	77,620



TABLE II
SUMMARY OF INSTRUMENTATION AND ACCURACIES

Quantities measured	Instrument used	Units	Instrument accuracy excluding reproduction error (units as given)	Reproduction accuracy (units as given)	Instrument natural frequency, cps
Pressure altitude	Airspeed-altitude recorder	feet	-----	±50	>100 (diaphragm)
Indicated airspeed	Airspeed-altitude recorder	knots	-----	-----	>100 (diaphragm)
Rudder angle	Control-position recorder	degrees	±0.4	±0.4	14
Aileron angle	Control-position recorder	degrees	±0.4	±0.3	14
Elevator angle	Control-position recorder	degrees	±0.4	±0.4	14
Normal load factor	Single-component accelerometer	-----	±0.025	±0.05	17.8
Longitudinal load factor	Three-component accelerometer	-----	±0.01	±0.02	5.7
Transverse load factor	Three-component accelerometer	-----	±0.01	±0.02	13.0
Pitching velocity	Angular-velocity recorder	$\frac{\text{radians}}{\text{sec}}$	±0.02	±0.01	14.85
Pitching acceleration	Angular accelerometer	$\frac{\text{radians}}{\text{sec}^2}$	±0.03	±0.02	14.25 (transmitter) 7.2 (galvanometer)
Yawing velocity	Angular-velocity recorder	$\frac{\text{radians}}{\text{sec}}$	±0.01	±0.005	9.5
Yawing acceleration	Angular accelerometer	$\frac{\text{radians}}{\text{sec}^2}$	±0.04	±0.01	9.5 (transmitter) 7.1 (galvanometer)
Rolling velocity	Angular-velocity recorder	$\frac{\text{radians}}{\text{sec}}$	±0.10	±0.05	25.5
Rolling acceleration	Angular accelerometer	$\frac{\text{radians}}{\text{sec}^2}$	±0.40	±0.10	25.5 (transmitter) 7 (galvanometer)
Sideslip angle	Flow-direction recorder	degrees	±0.1	±0.3	18
Angle of attack	Flow-direction recorder	degrees	±0.1	±0.3	18
Time	Timer	seconds	0	±0.5 sec in 60 sec (over-all) ±0.1 sec (synchronization)	-----

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TABLE III
MANEUVER CLASSIFICATION AND ARRANGEMENT

Maneuver classification	Figure
Take-off	3 to 20
Turn	21 to 77
Roll	78 to 158
Wing-over	159 to 168
Chandelle	169 to 182
Lazy eight	183 to 185
Pull-up	186 to 201
Loop	202 to 210
Immelman	211 to 219
Split-S	220 to 230
Sideslip	231 and 232
Rudder kicks	233
Stall	234 to 243
Series of maneuvers	244 to 285
Directional oscillation	286
Interception	287
Landing	288 to 303





Figure 1.- Photograph of F-94B test airplane.



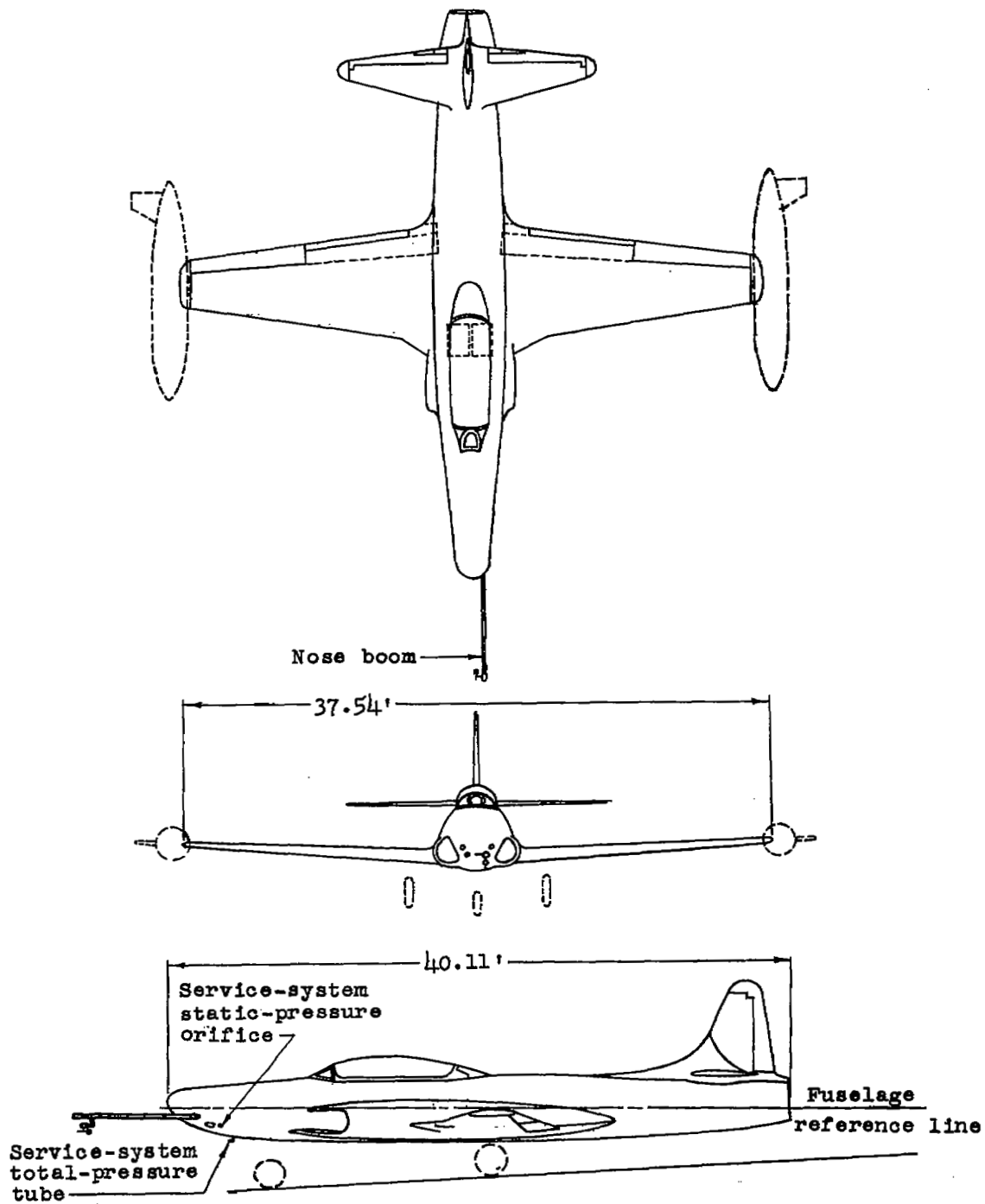


Figure 2.- Three-view drawing of F-94B test airplane.



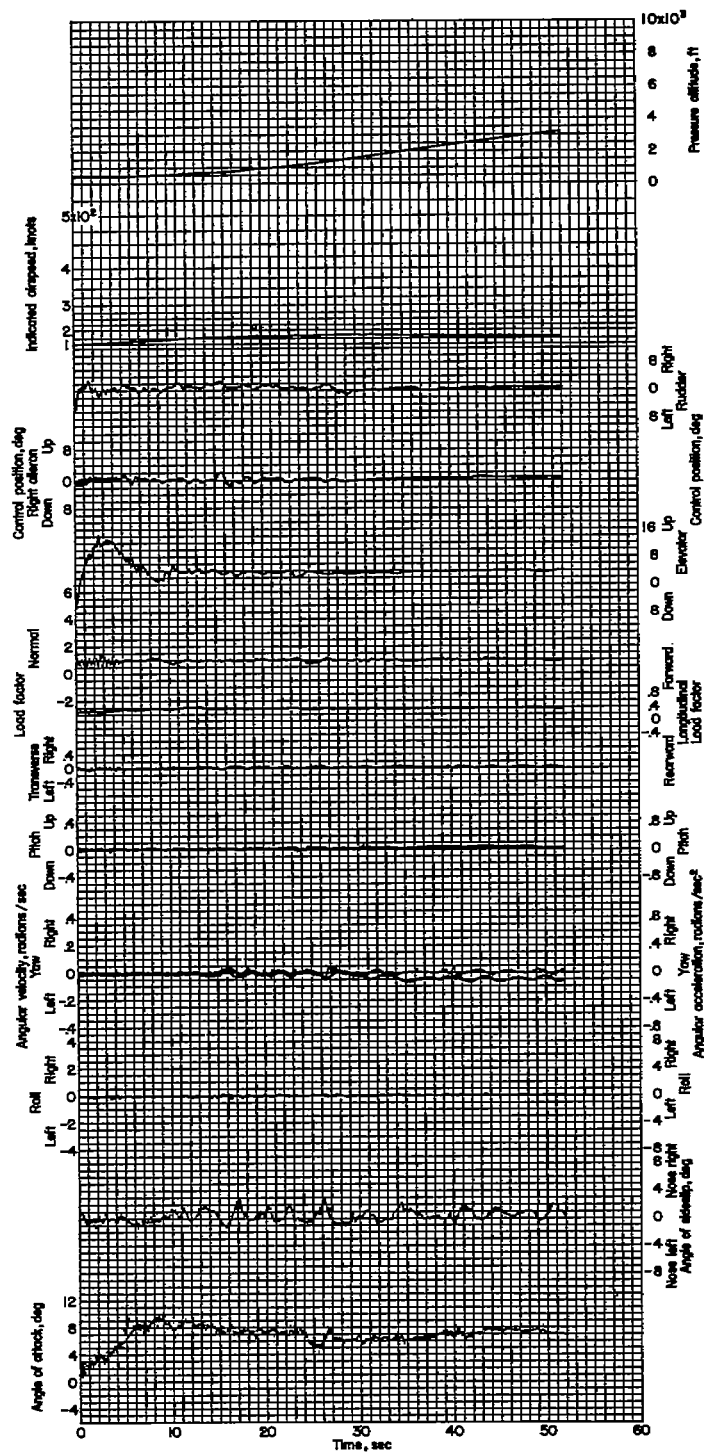


Figure 3.- Take-off. Pilot A; airplane weight, 12,680 pounds; center of gravity at 27.7 percent M.A.C.

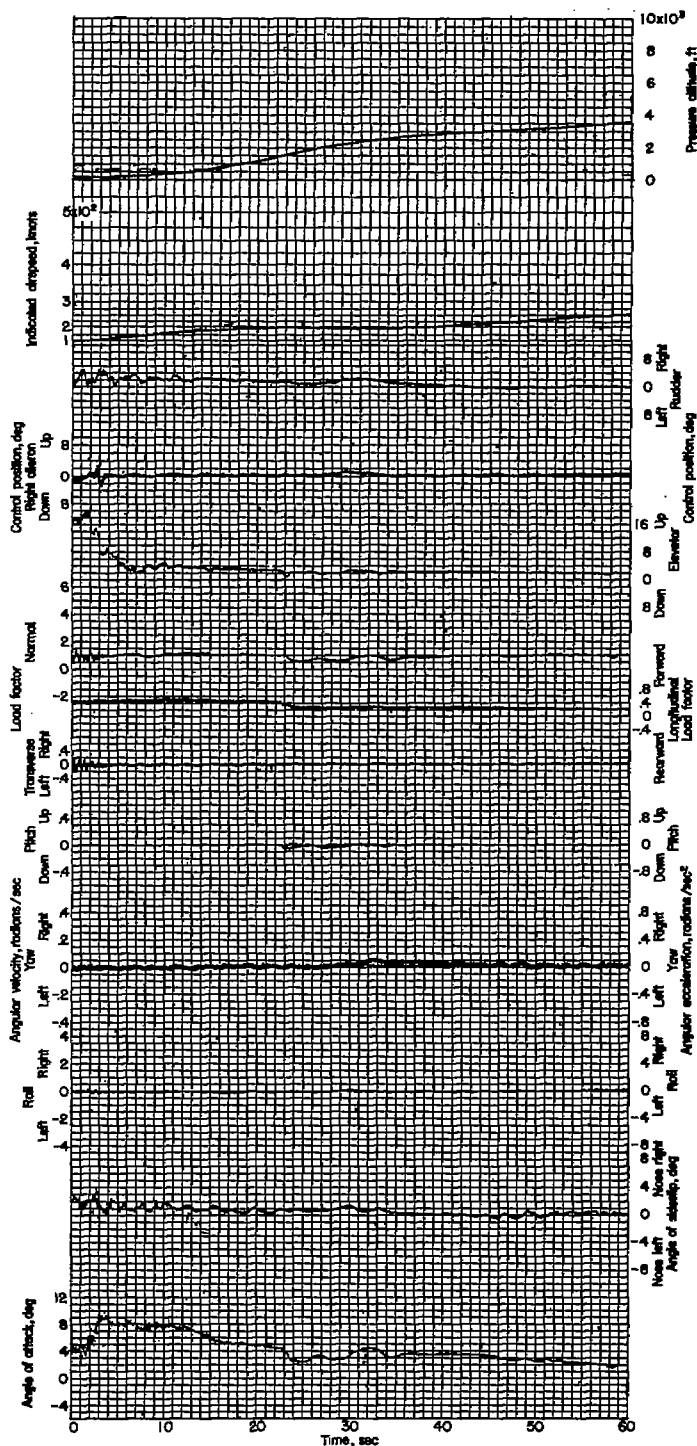
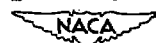


Figure 4.- Take-off. Pilot A; airplane weight, 12,855 pounds; center of gravity at 27.6 percent M.A.C.



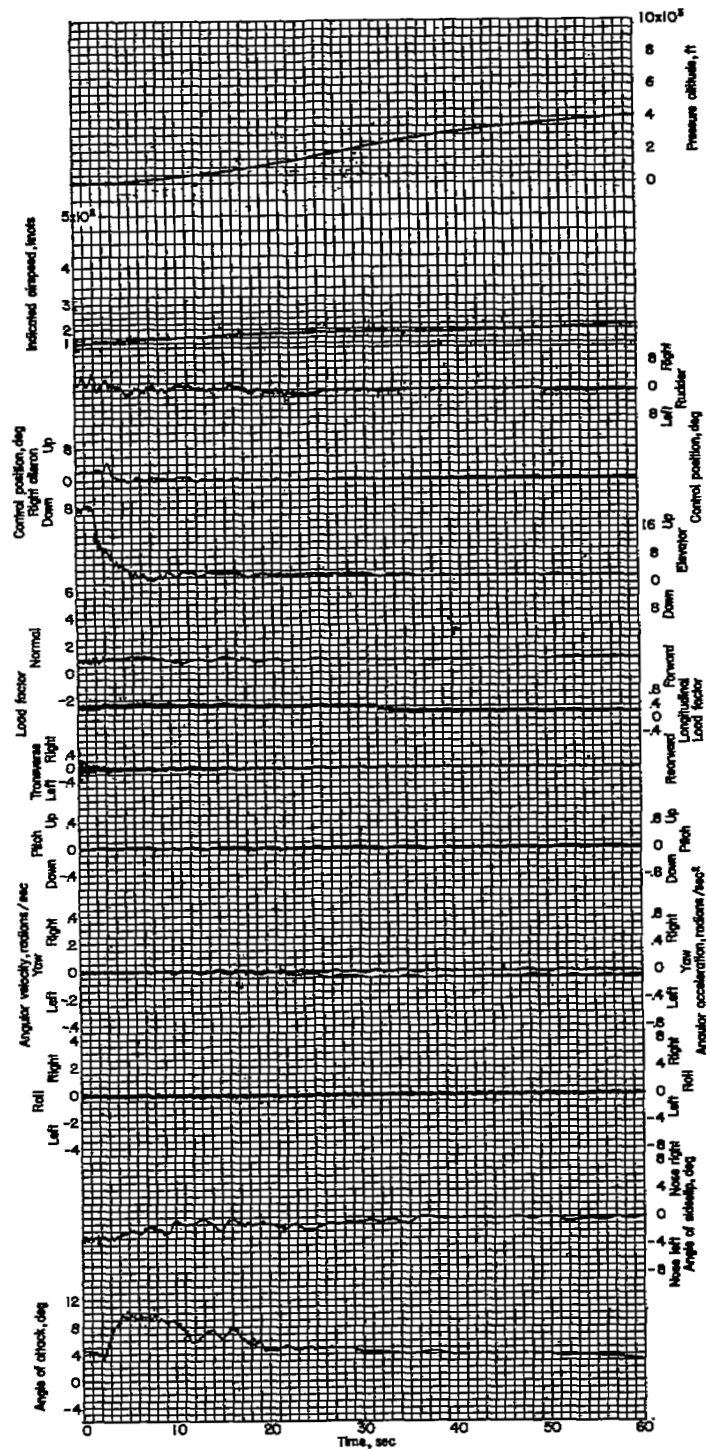
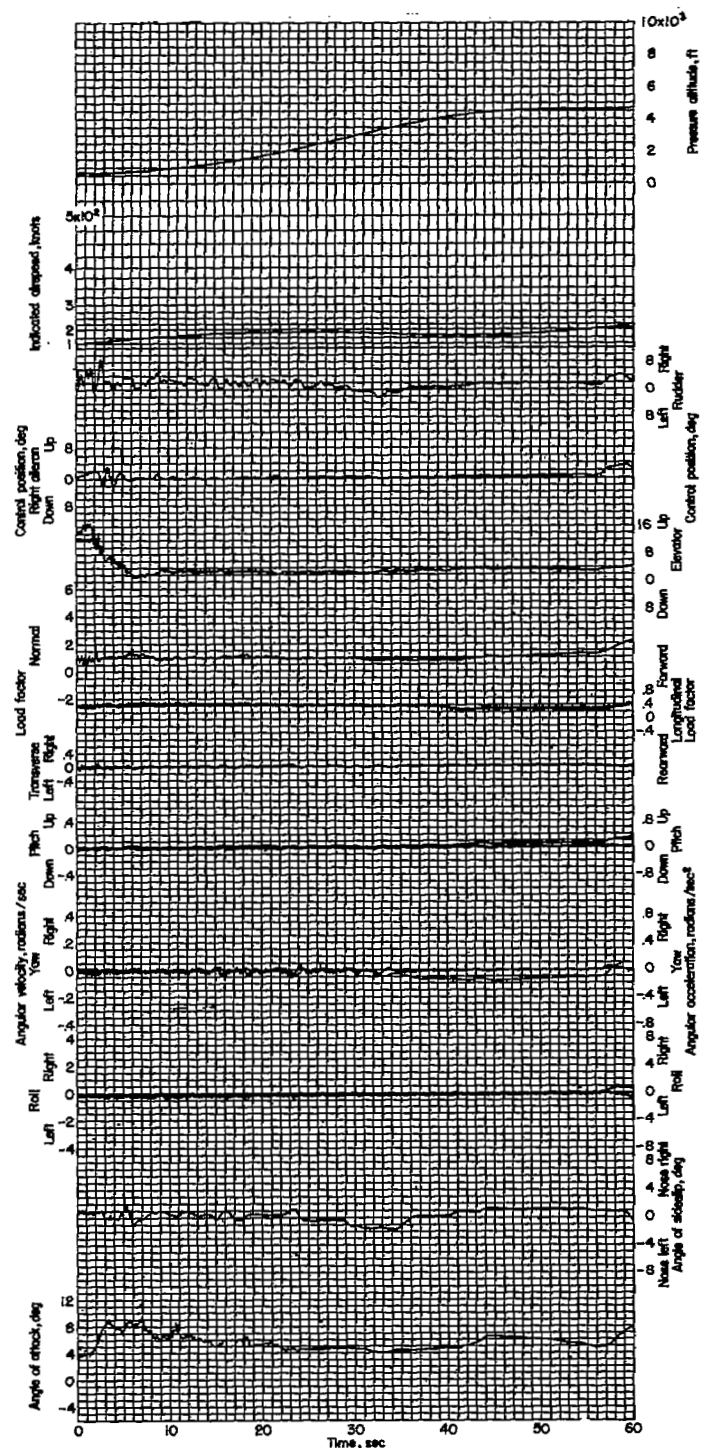


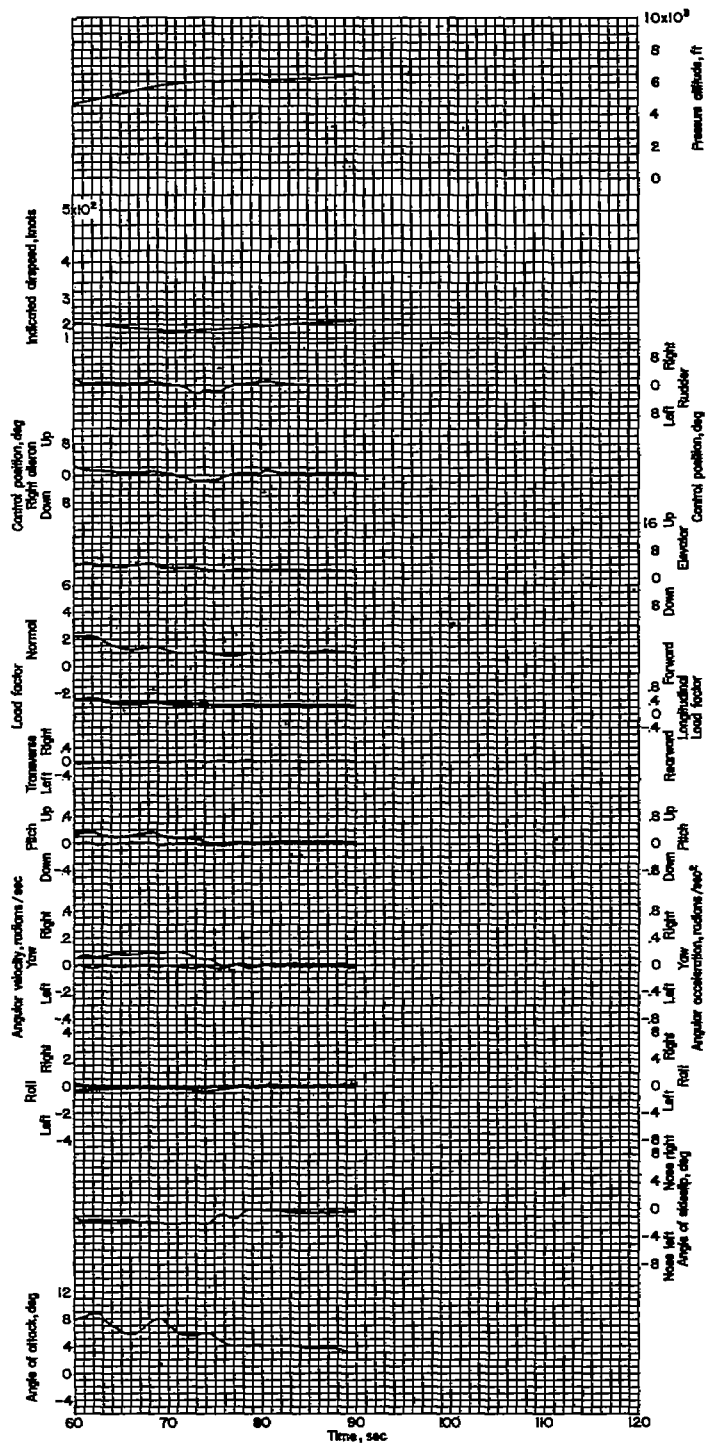
Figure 5.- Take-off. Pilot A; airplane weight, 12,780 pounds; center of gravity at 27.6 percent M.A.C.



(a)



Figure 6.- Take-off. Pilot A wearing anti-gravity suit; airplane weight, 12,570 pounds; center of gravity at 27.7 percent M.A.C.,



(b)

Figure 6.- Concluded.



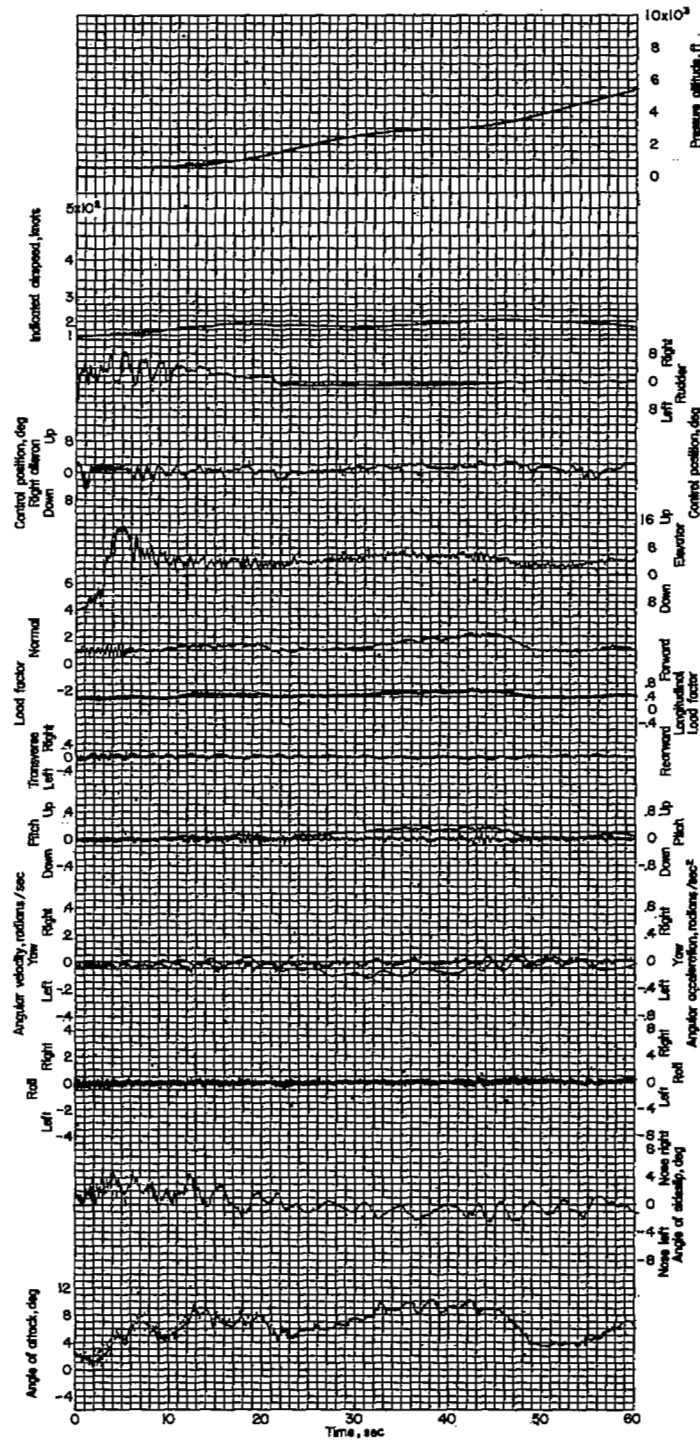
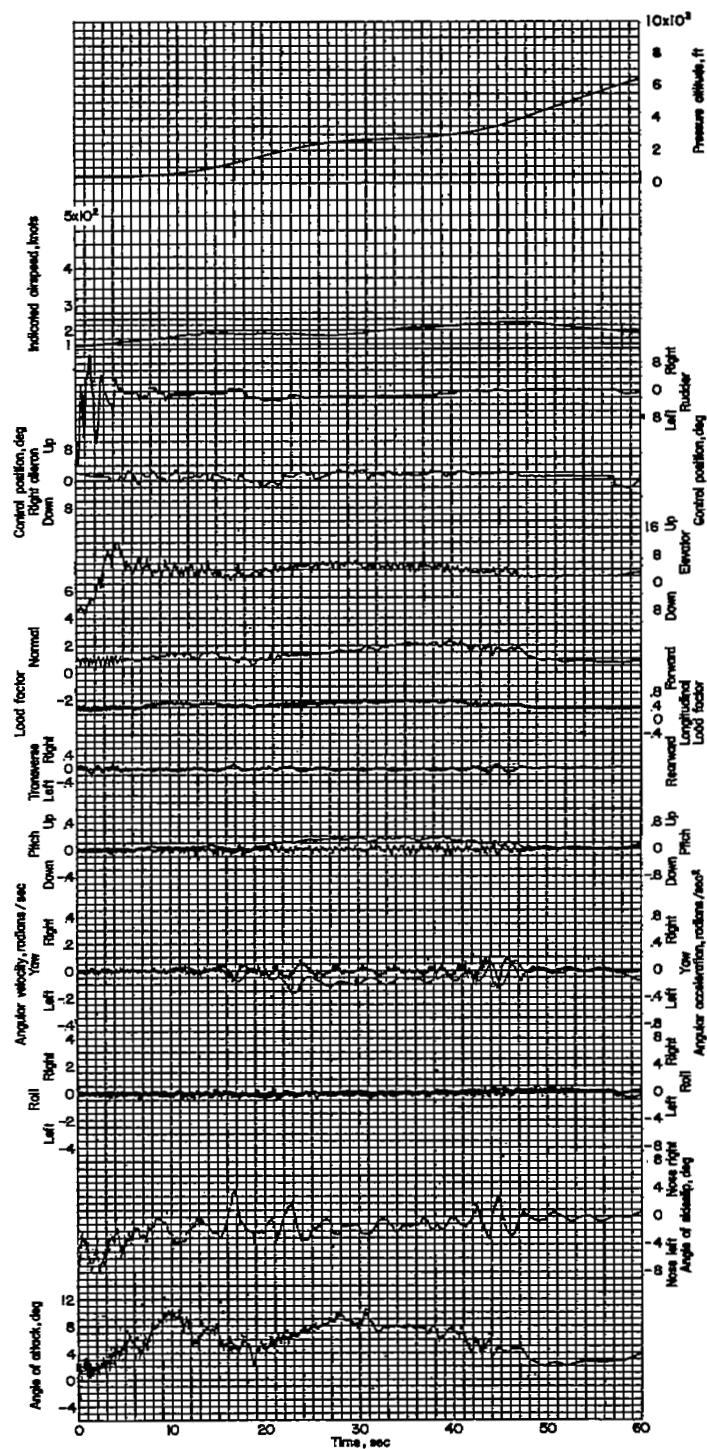


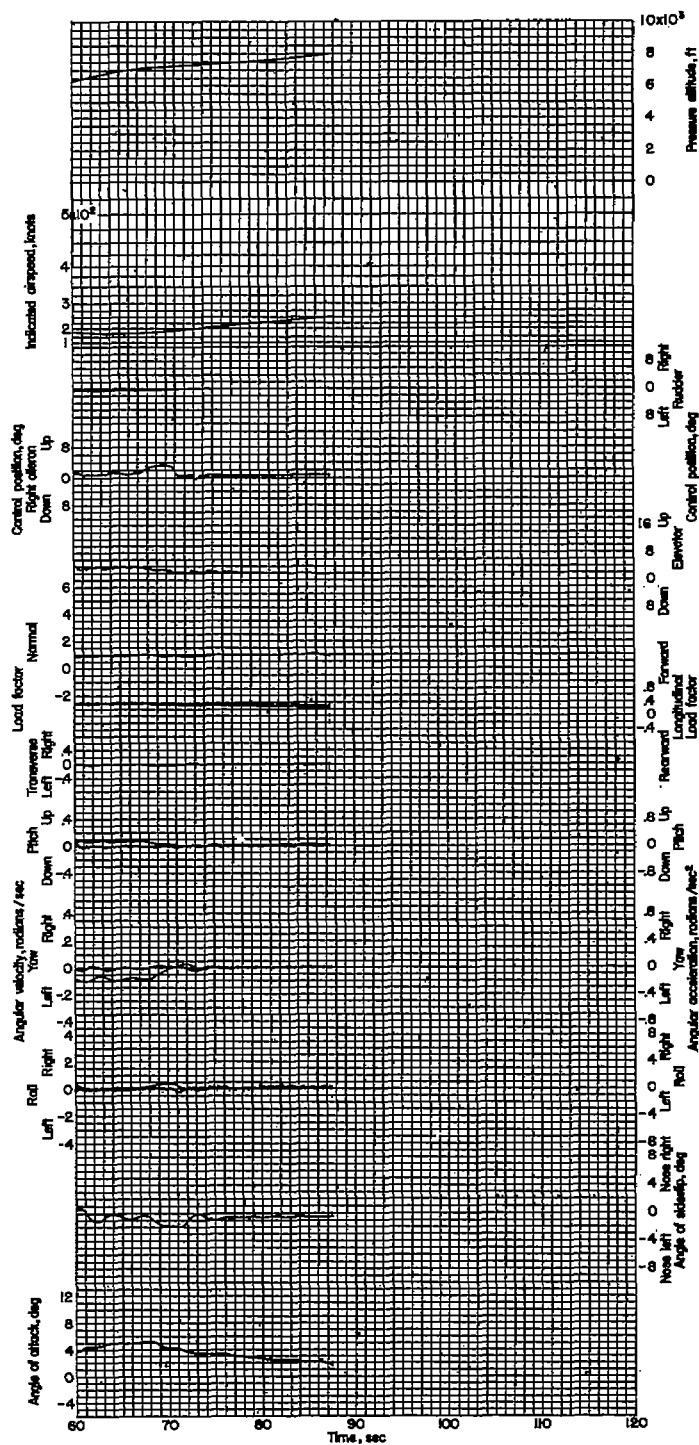
Figure 7.- Take-off. Pilot B; airplane weight, 12,890 pounds; center of gravity at 27.6 percent M.A.C.



(a)



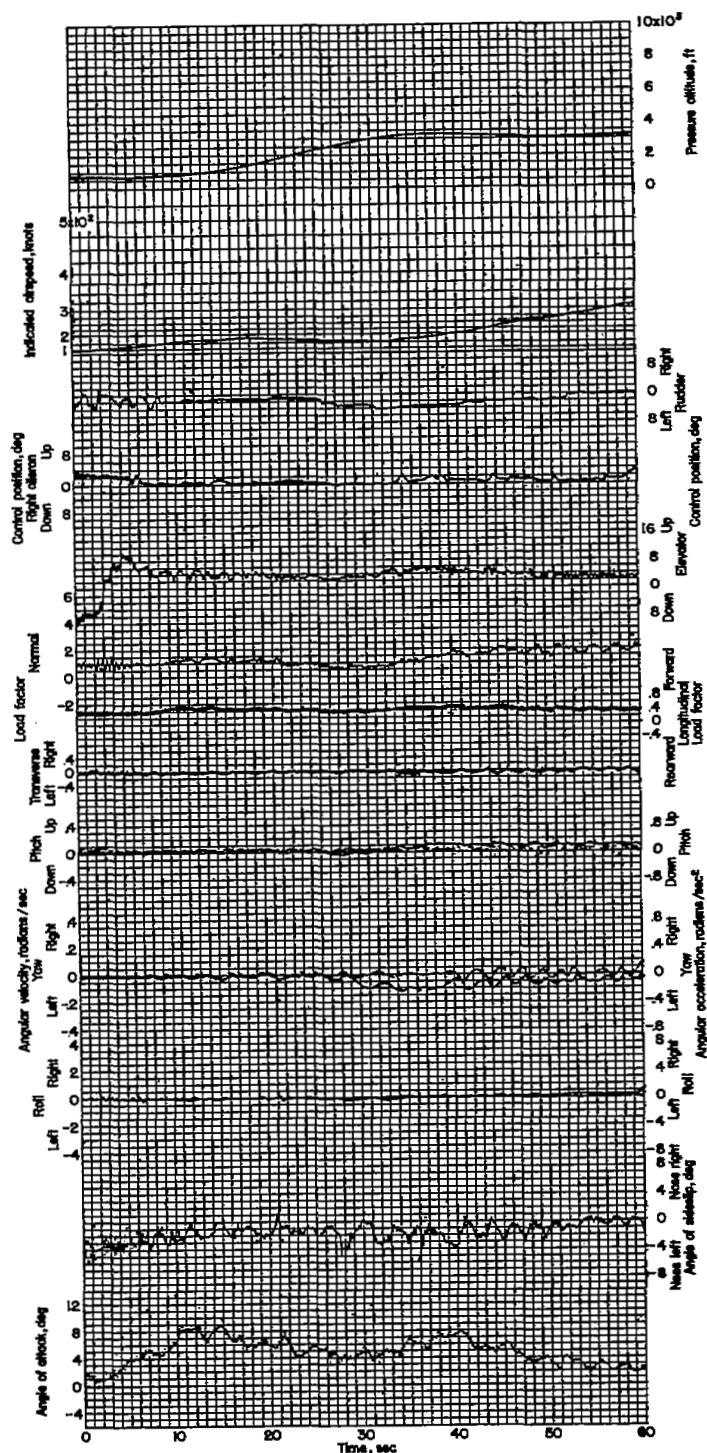
Figure 8.- Take-off. Pilot B; airplane weight, 12,570 pounds; center of gravity at 27.7 percent M.A.C.



(b)

Figure 8.- Concluded.

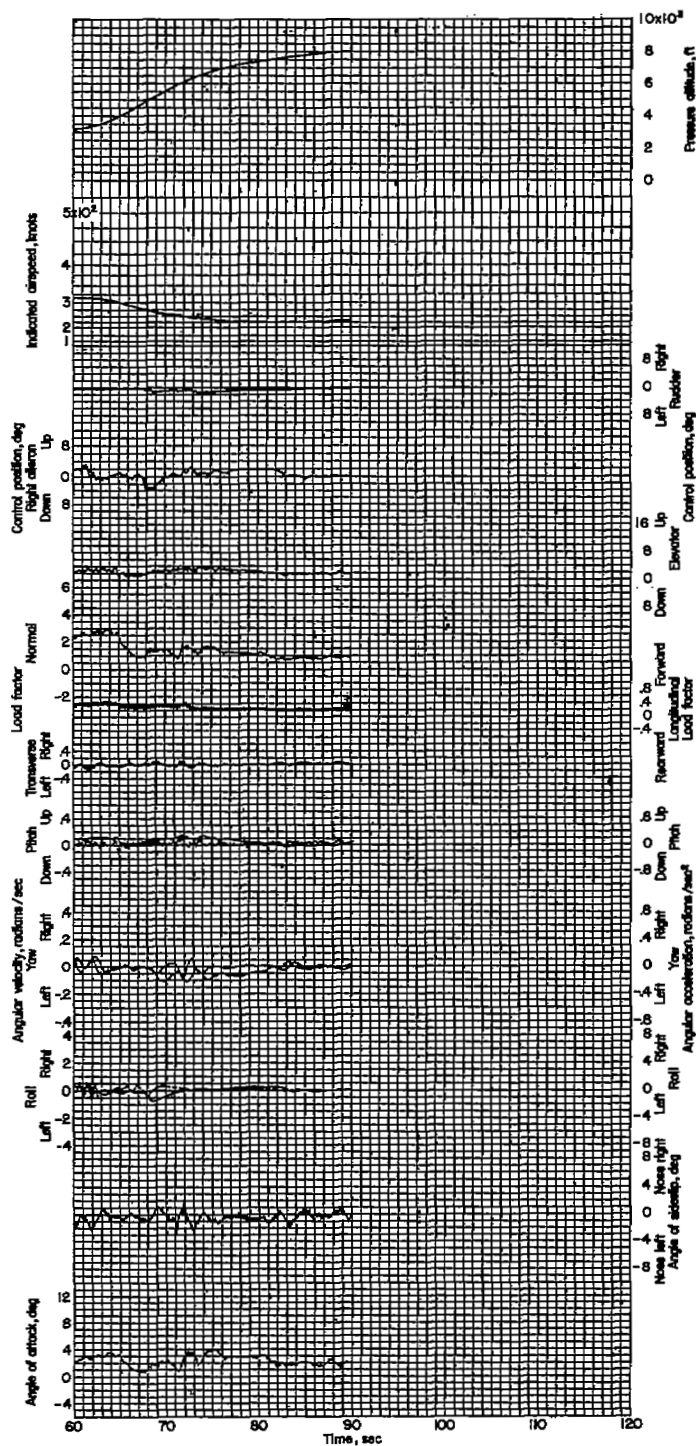




(a)



Figure 9.- Take-off. Pilot B with radar observer; airplane weight, 12,900 pounds; center of gravity at 26.9 percent M.A.C.



(b)

Figure 9.- Concluded.



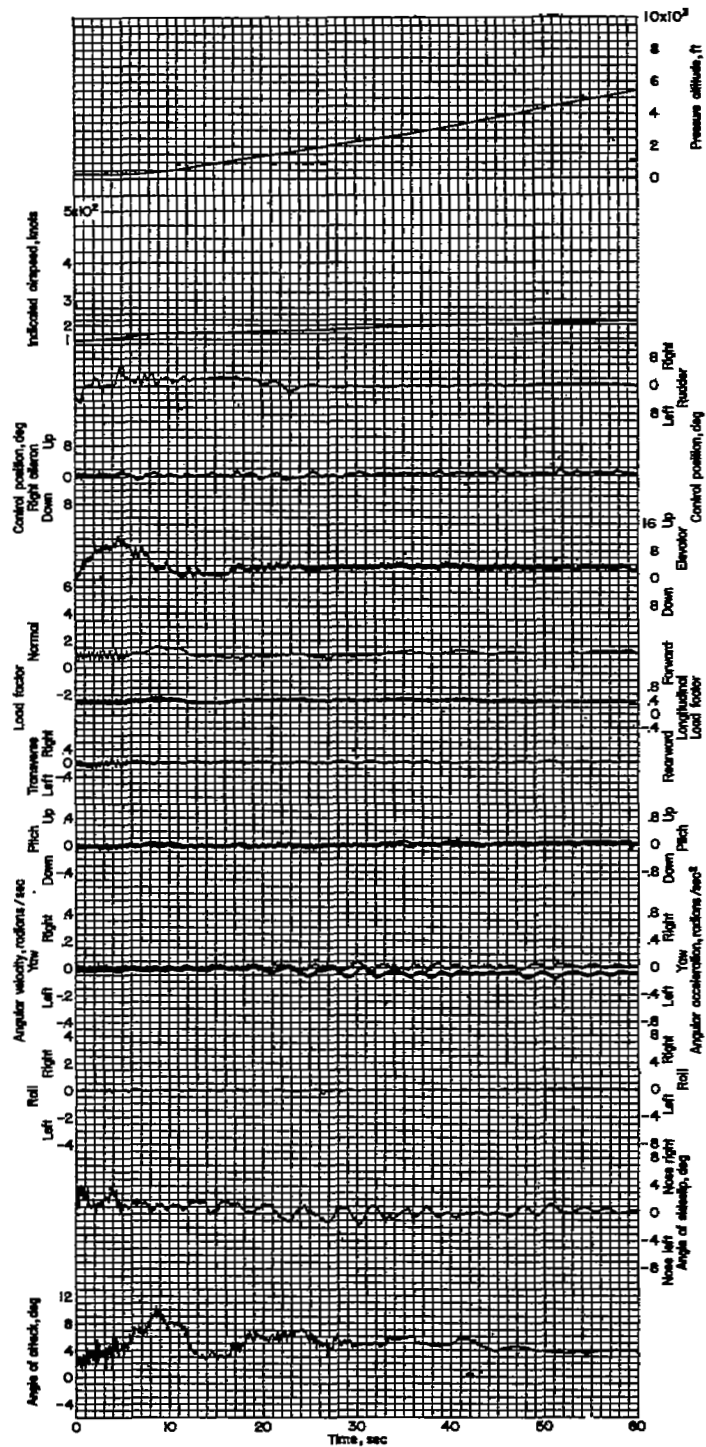


Figure 10.- Take-off. Pilot C with radar observer; airplane weight, 13,200 pounds; center of gravity at 26.8 percent M.A.C.

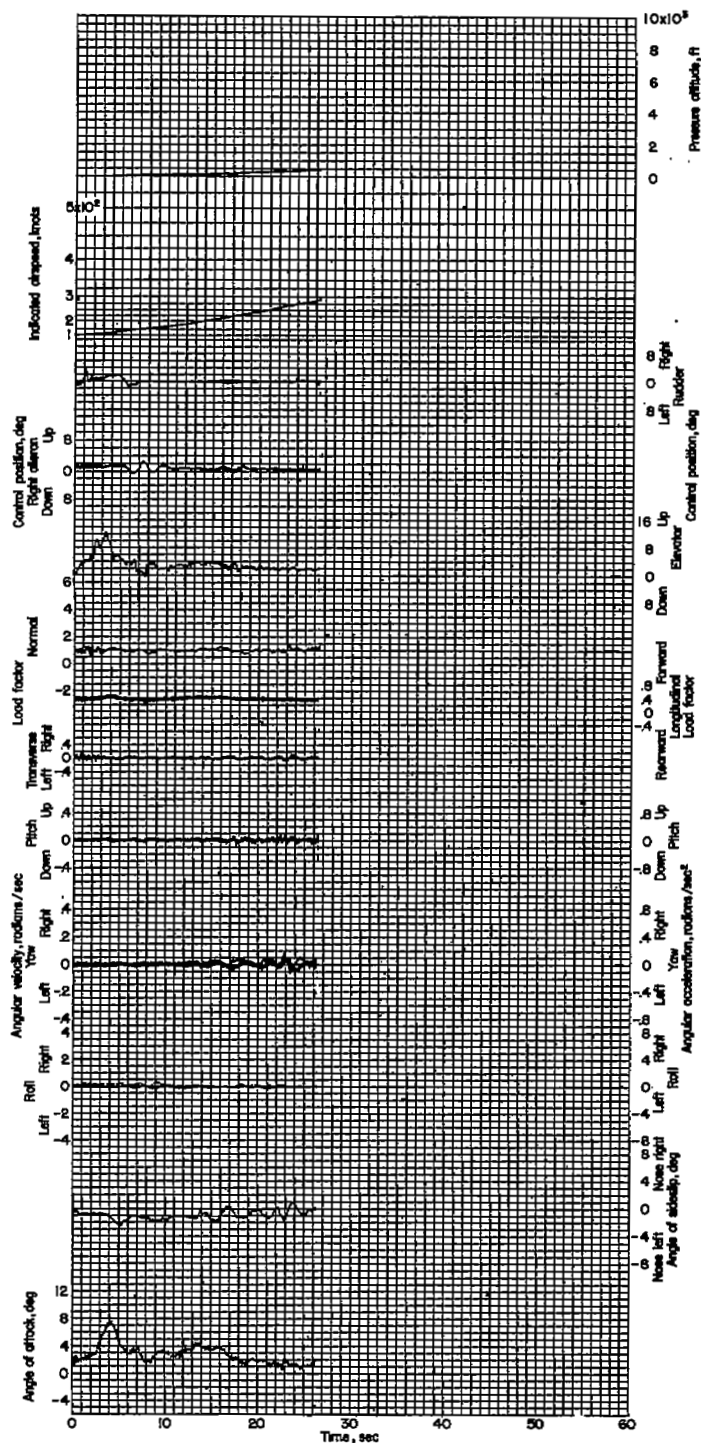


Figure 11.- Take-off. Pilot D with radar observer; airplane weight, 13,200 pounds; center of gravity at 26.8 percent M.A.C.

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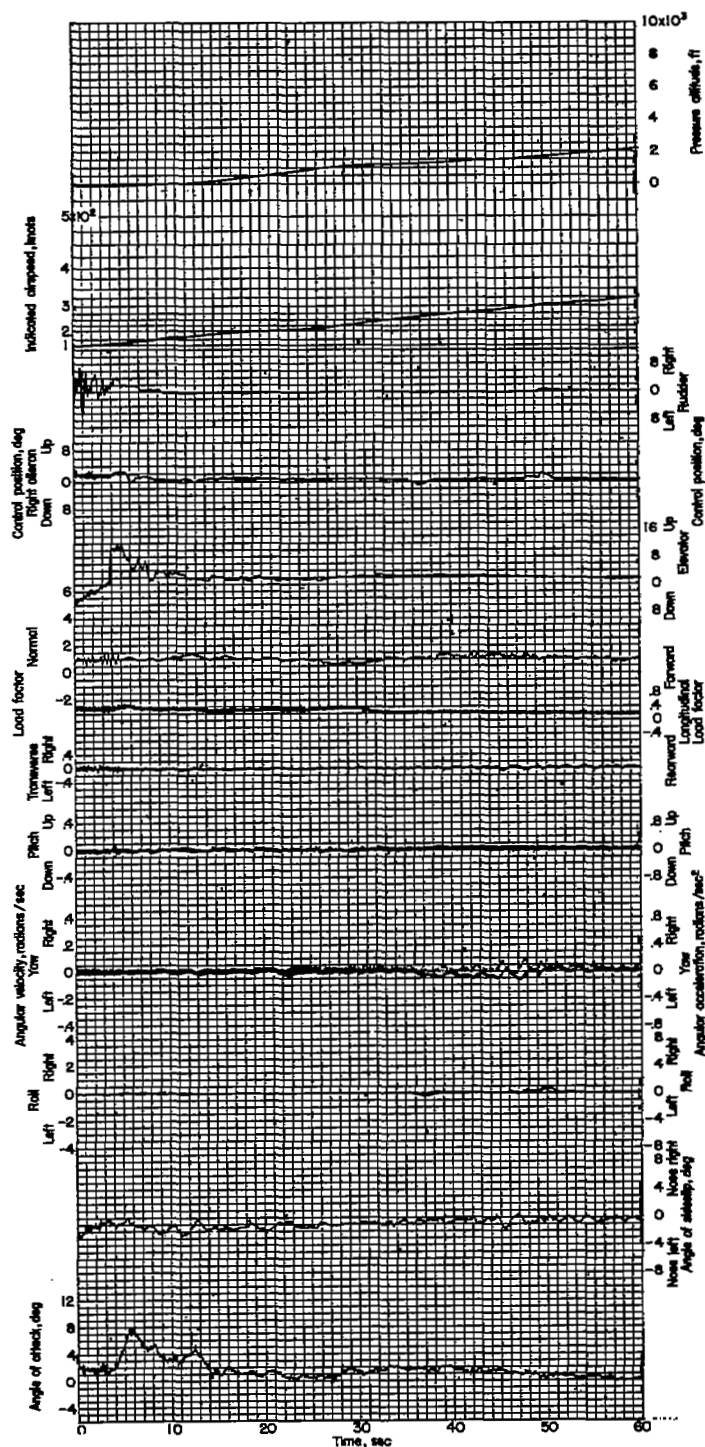


Figure 12.- Take-off. Pilot D with radar observer; airplane weight, 13,100 pounds; center of gravity at 26.8 percent M.A.C.

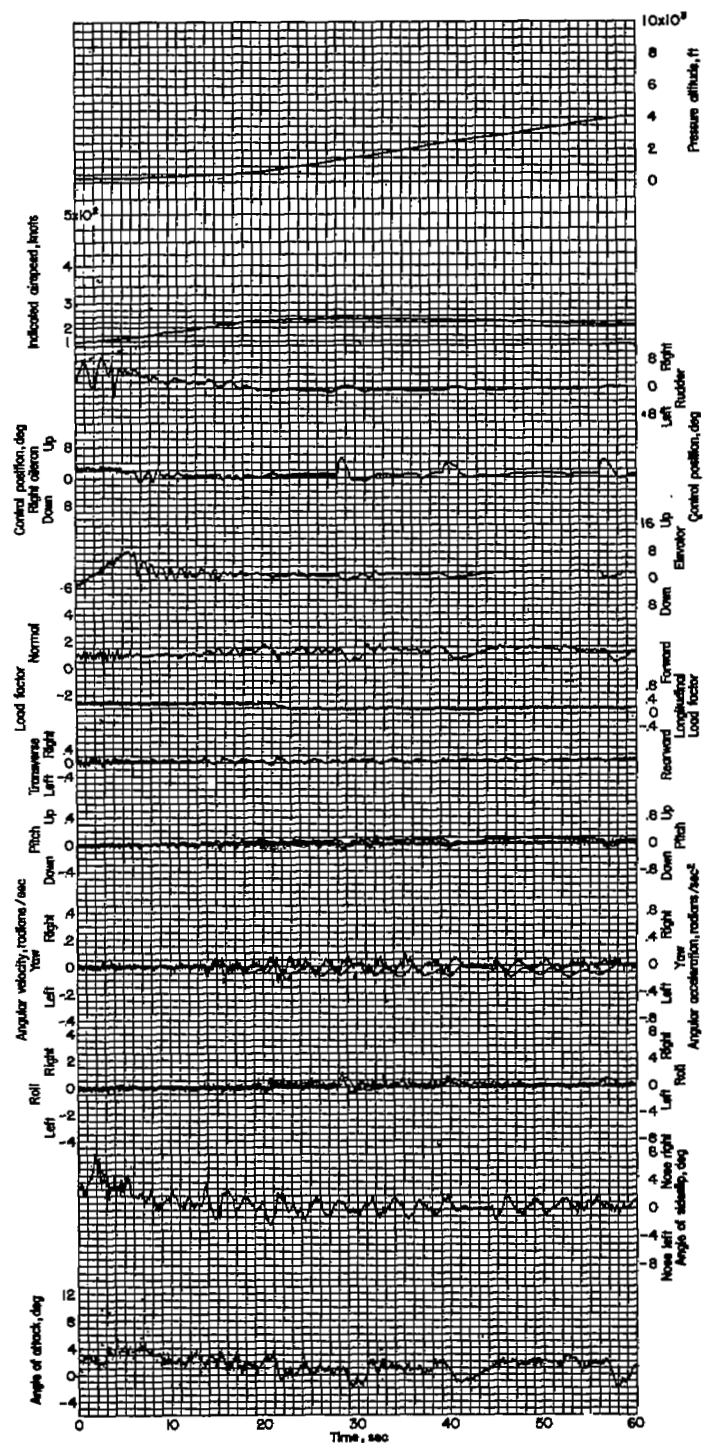
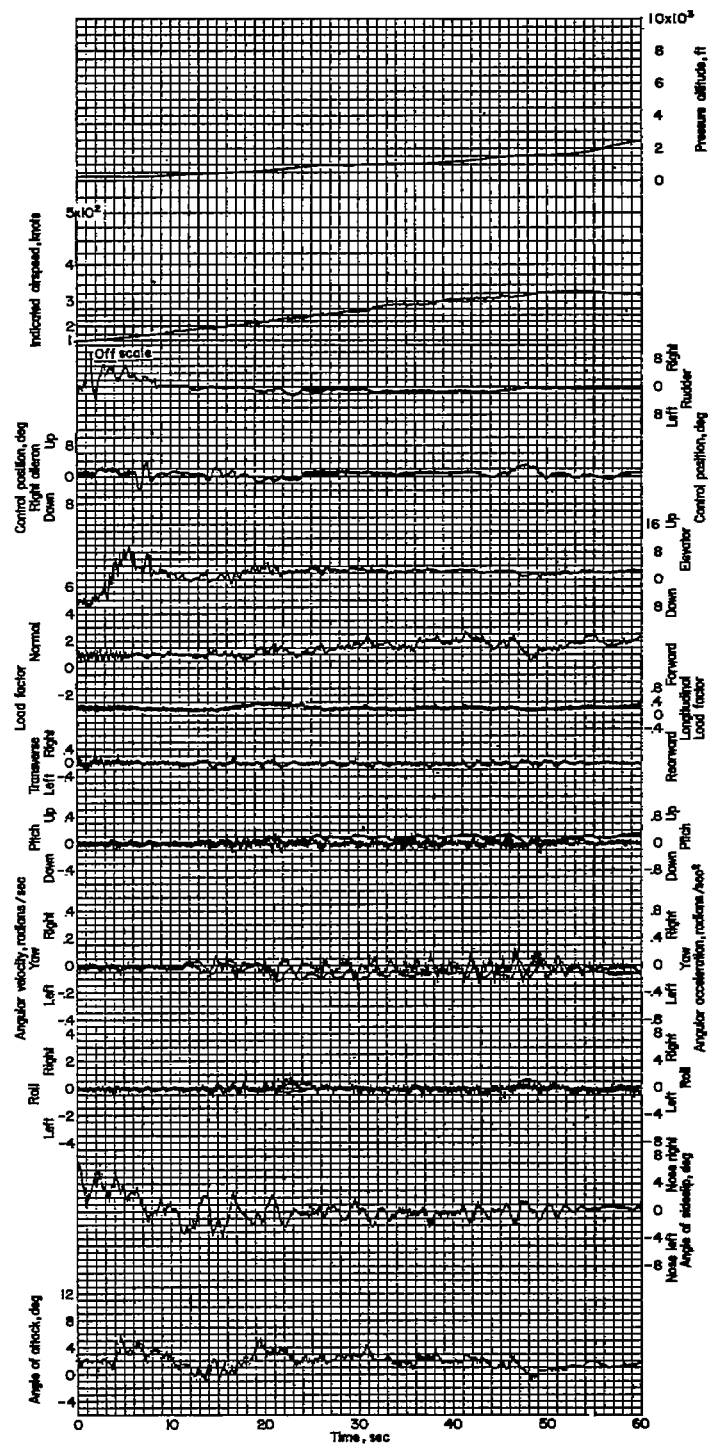


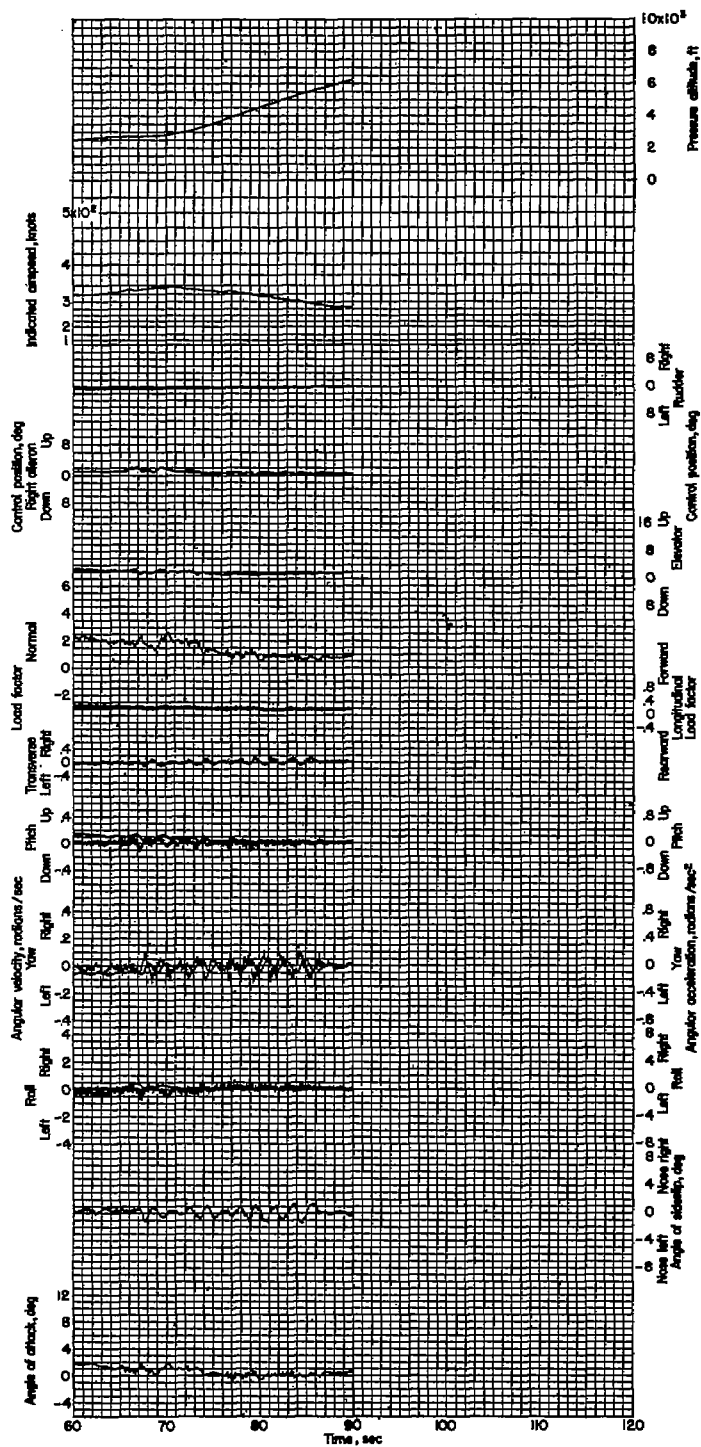
Figure 13.- Take-off. Pilot E wearing anti-gravity suit; airplane weight, 12,890 pounds; center of gravity at 27.6 percent M.A.C.



(a)

Figure 14.- Take-off. Pilot F wearing anti-gravity suit; airplane weight, 12,880 pounds; center of gravity at 27.6 percent M.A.C.

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(b)

Figure 14.- Concluded.



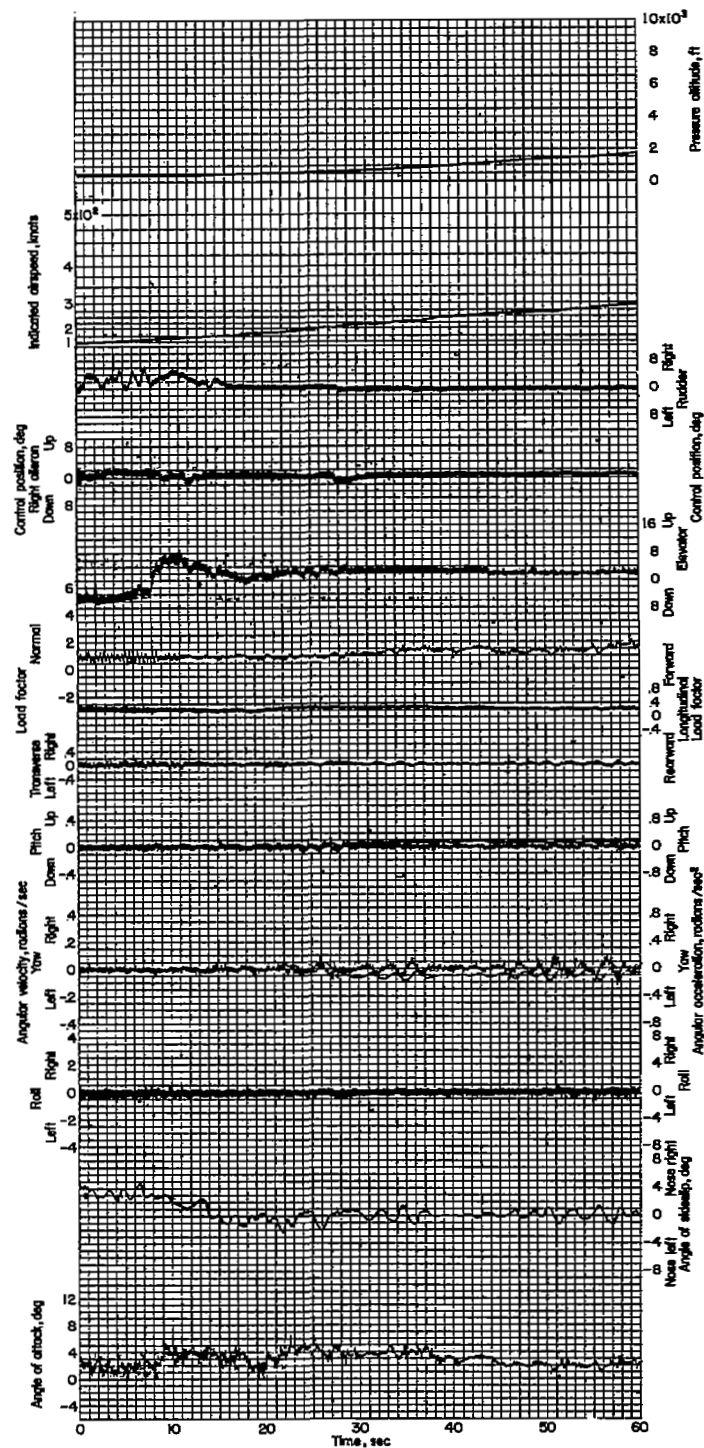


Figure 15.- Take-off. Pilot F wearing anti-gravity suit and with radar observer; airplane weight, 13,075 pounds; center of gravity at 26.8 percent M.A.C.

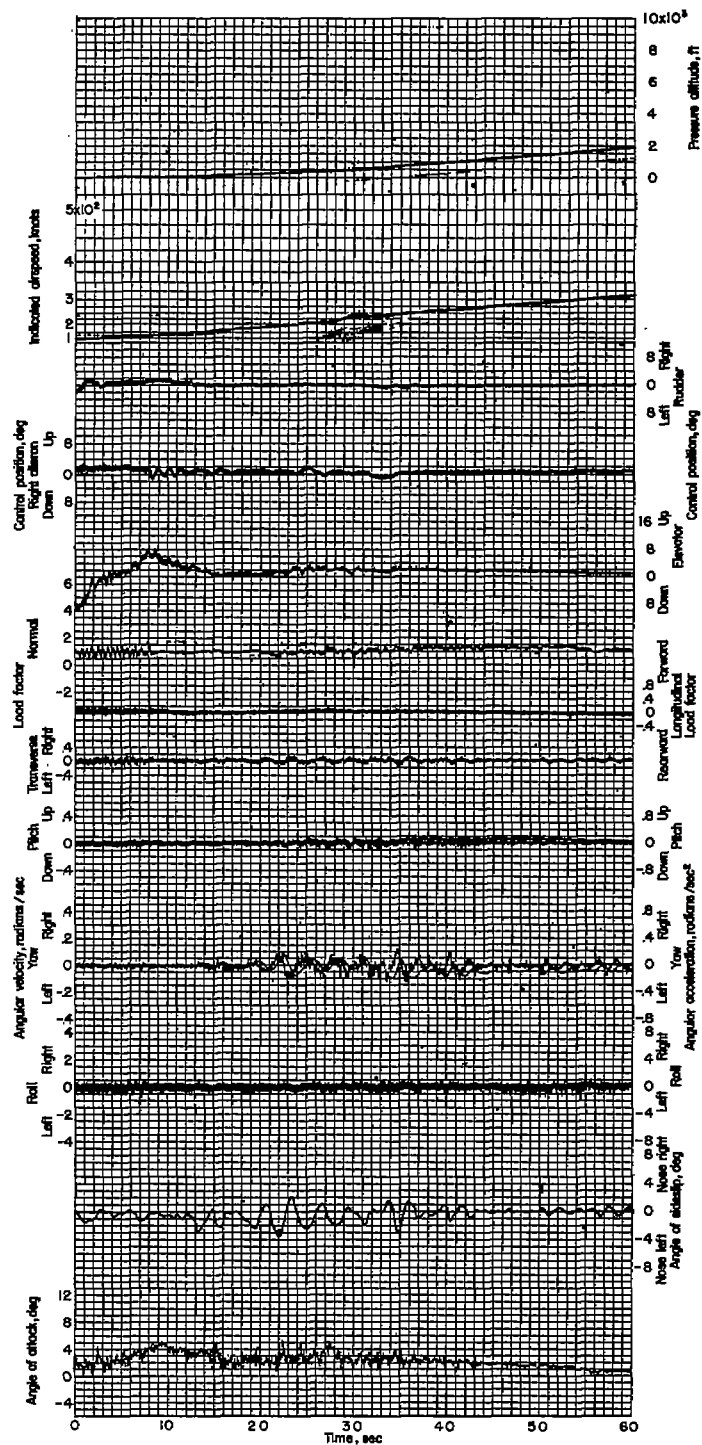
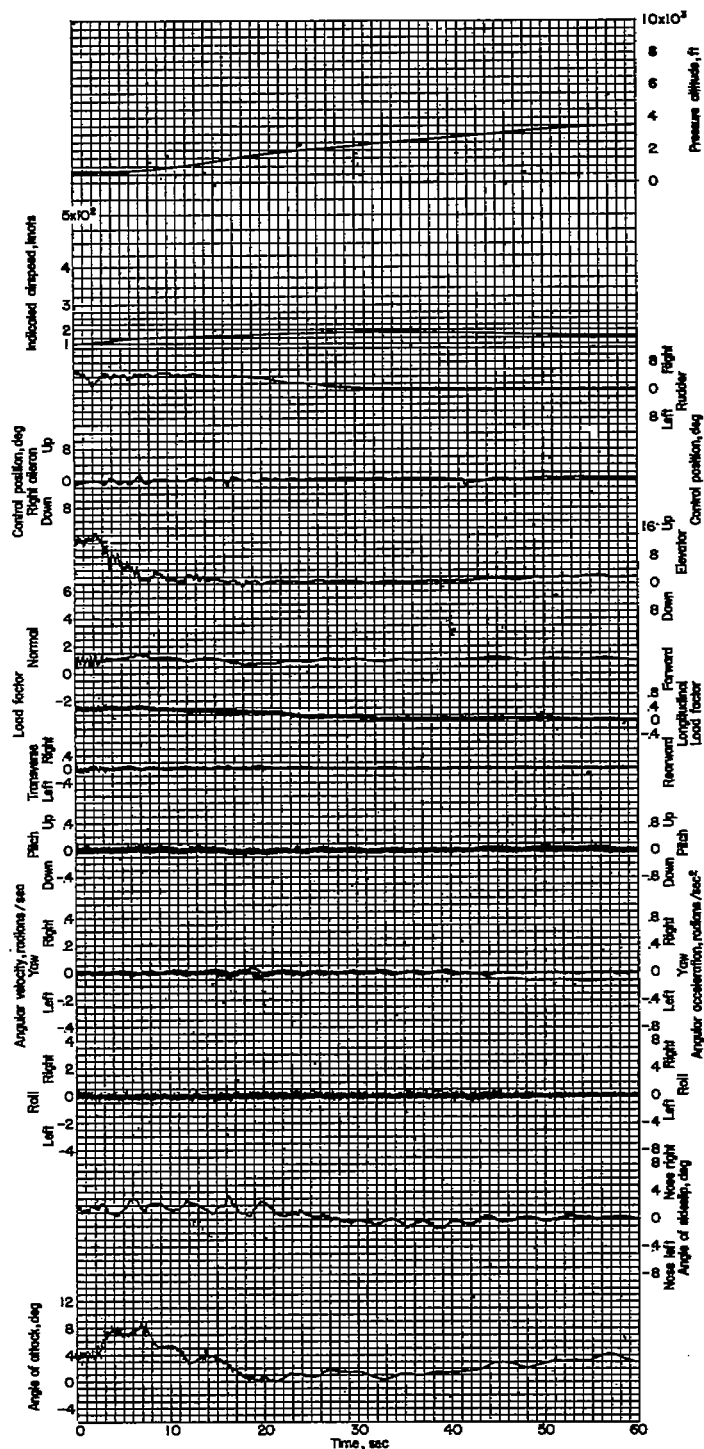


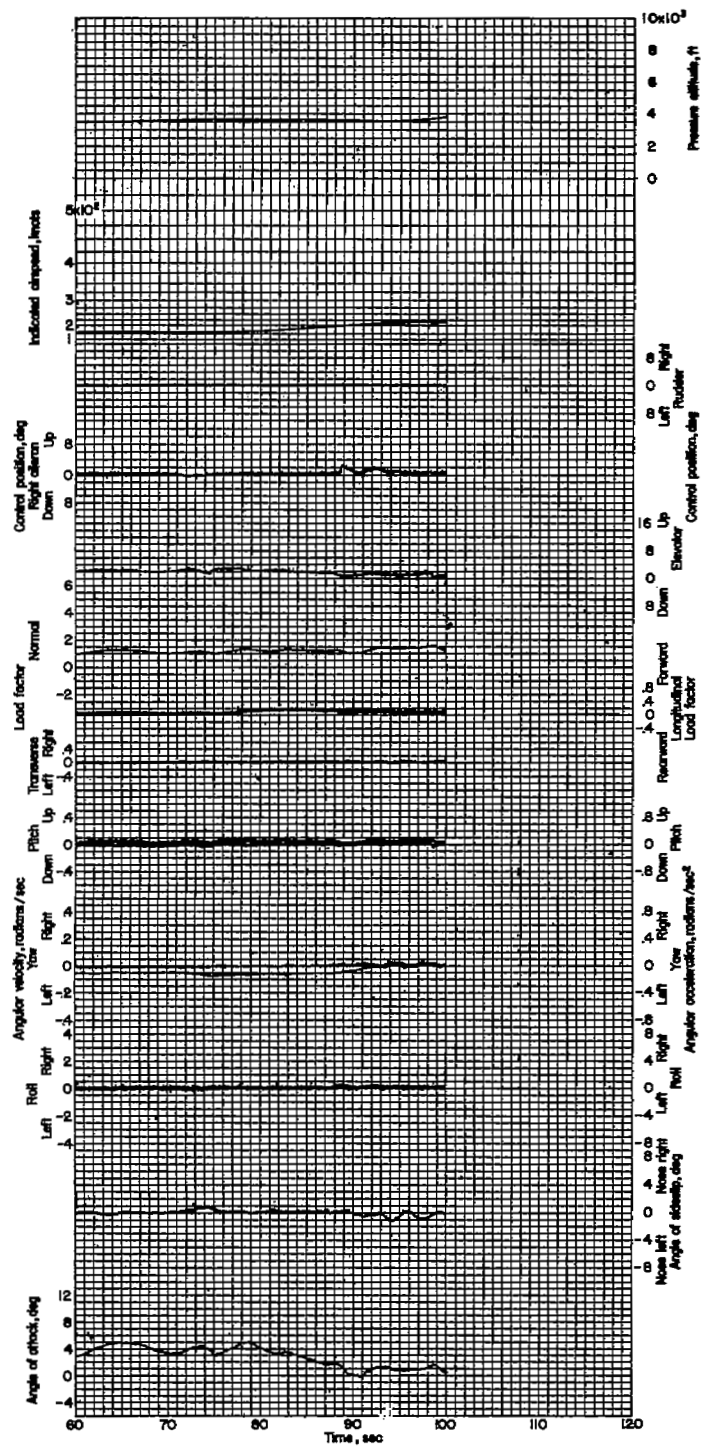
Figure 16.- Take-off. Pilot F wearing anti-gravity suit and with radar observer; airplane weight, 13,100 pounds; center of gravity at 26.8 percent M.A.C.



(a)



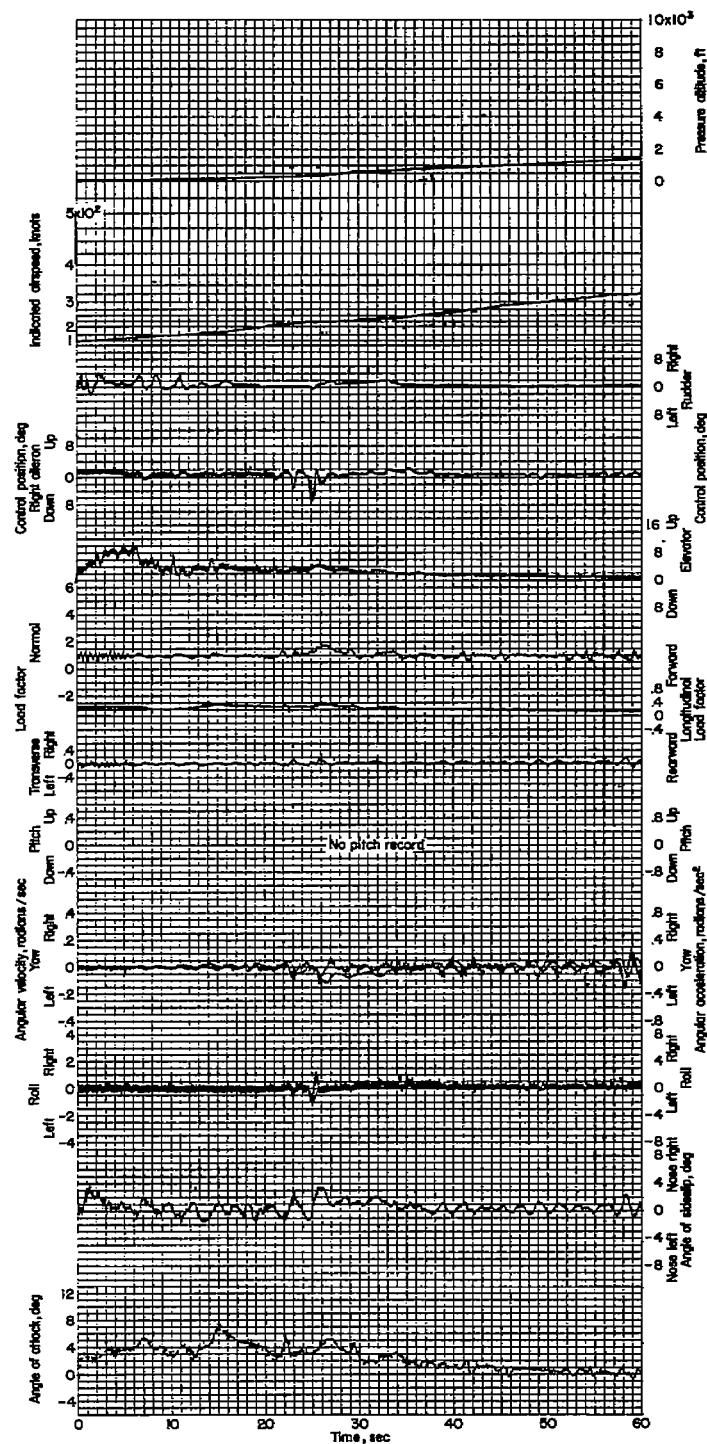
Figure 17.- Take-off. Pilot G; airplane weight, 12,820 pounds; center of gravity at 27.6 percent M.A.C.



(b)

Figure 17.- Concluded.

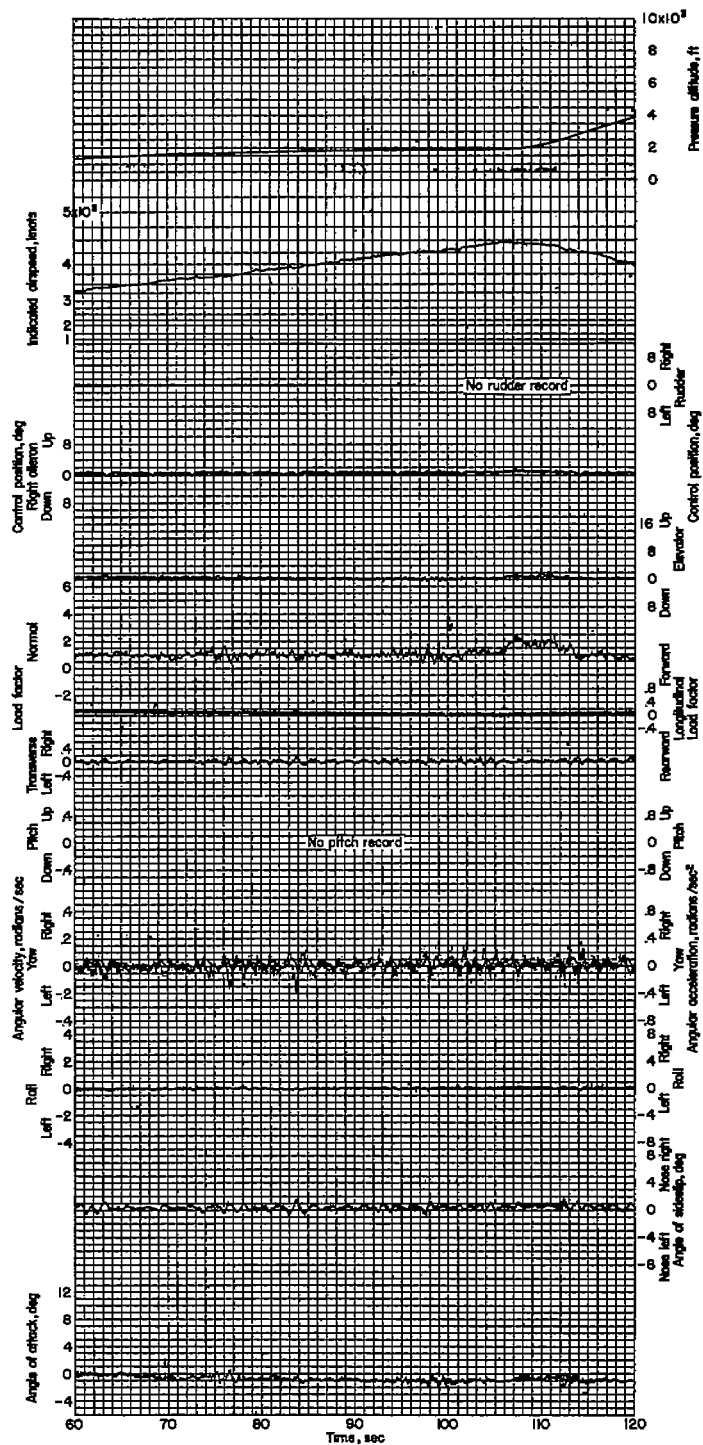




(a)



Figure 18.- Take-off. Pilot G with radar observer; airplane weight, 13,250 pounds; center of gravity at 26.8 percent M.A.C.



(b)

Figure 18.- Concluded.



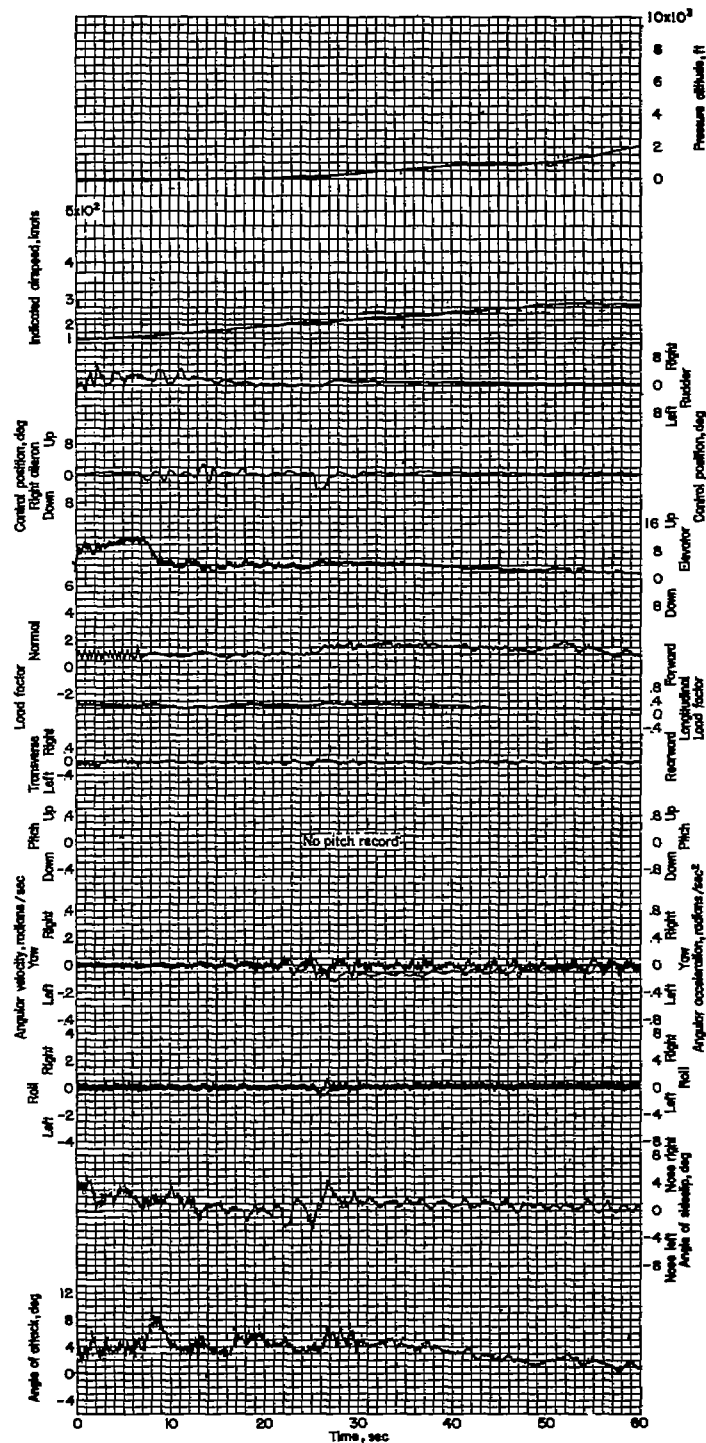


Figure 19.- Take-off. Pilot G with radar observer; airplane weight, 13,230 pounds; center of gravity at 26.8 percent M.A.C.



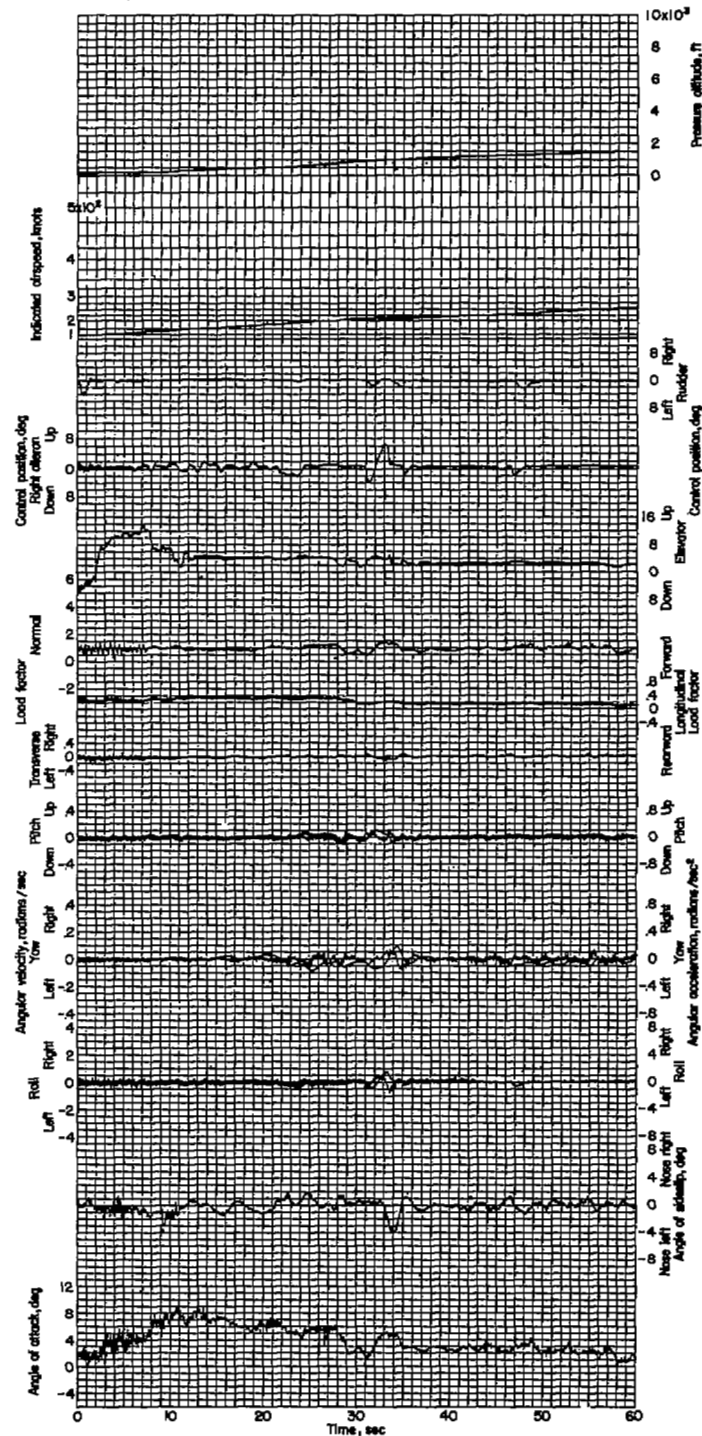


Figure 20.- Take-off. Pilot H with radar observer; airplane weight, 13,210 pounds; center of gravity at 26.8 percent M.A.C.

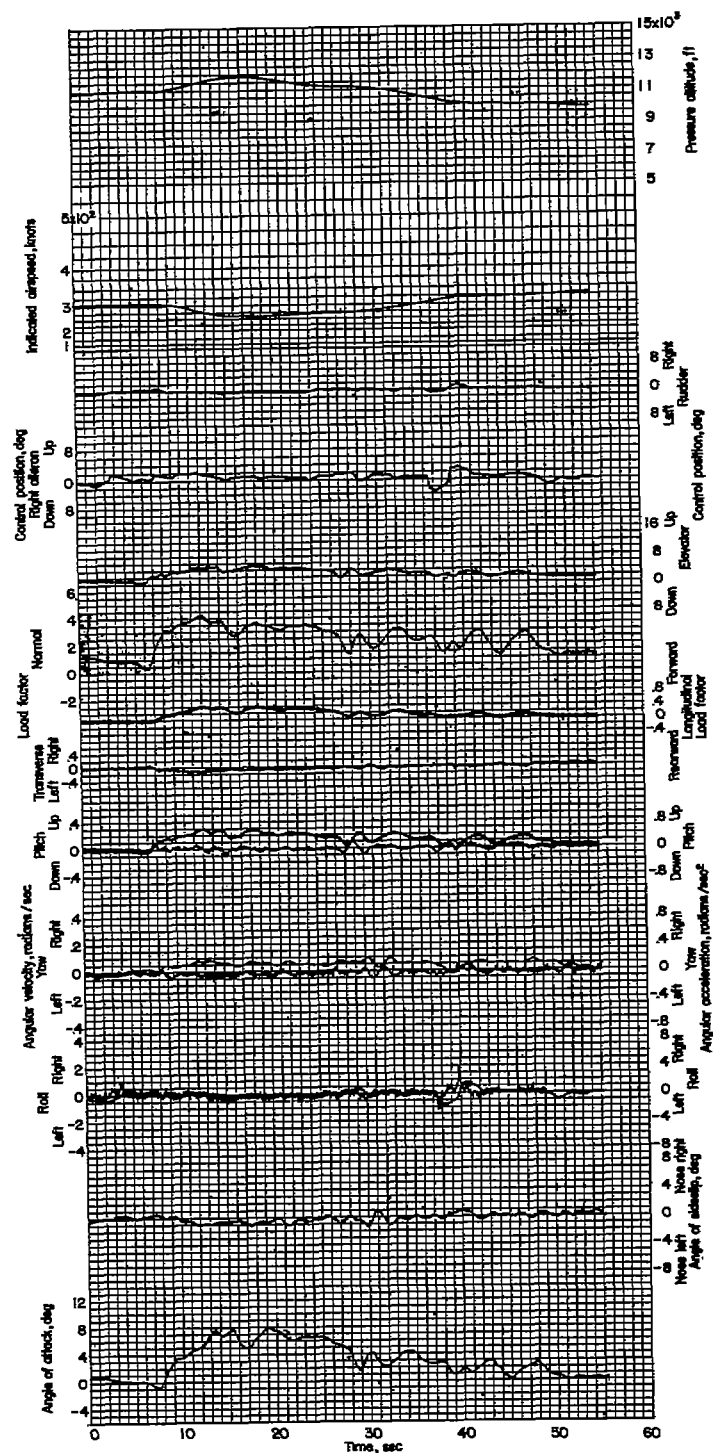


Figure 21.- Right turns. Pilot A wearing anti-gravity suit; airplane weight, 12,160 pounds; center of gravity at 27.2 percent M.A.C.

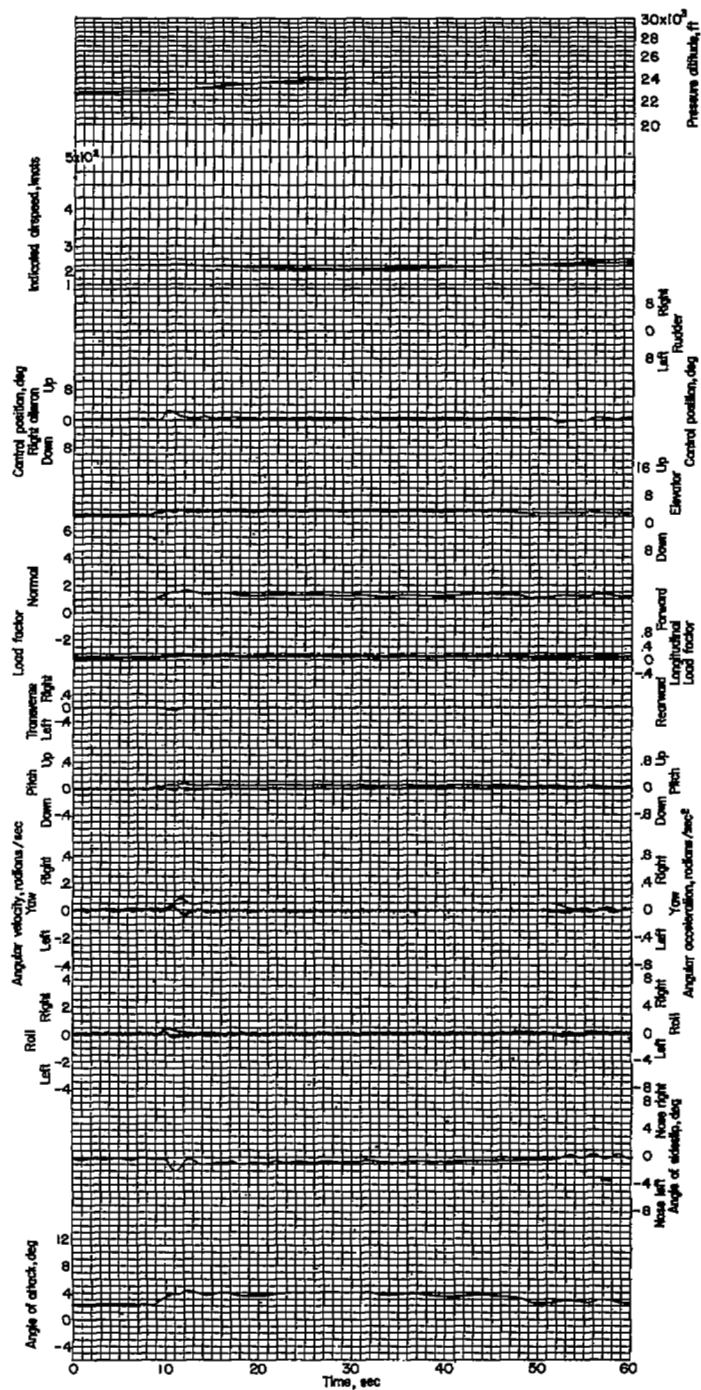


Figure 22.- Right turn. Pilot B; airplane weight, 12,410 pounds; center of gravity at 27.7 percent M.A.C.



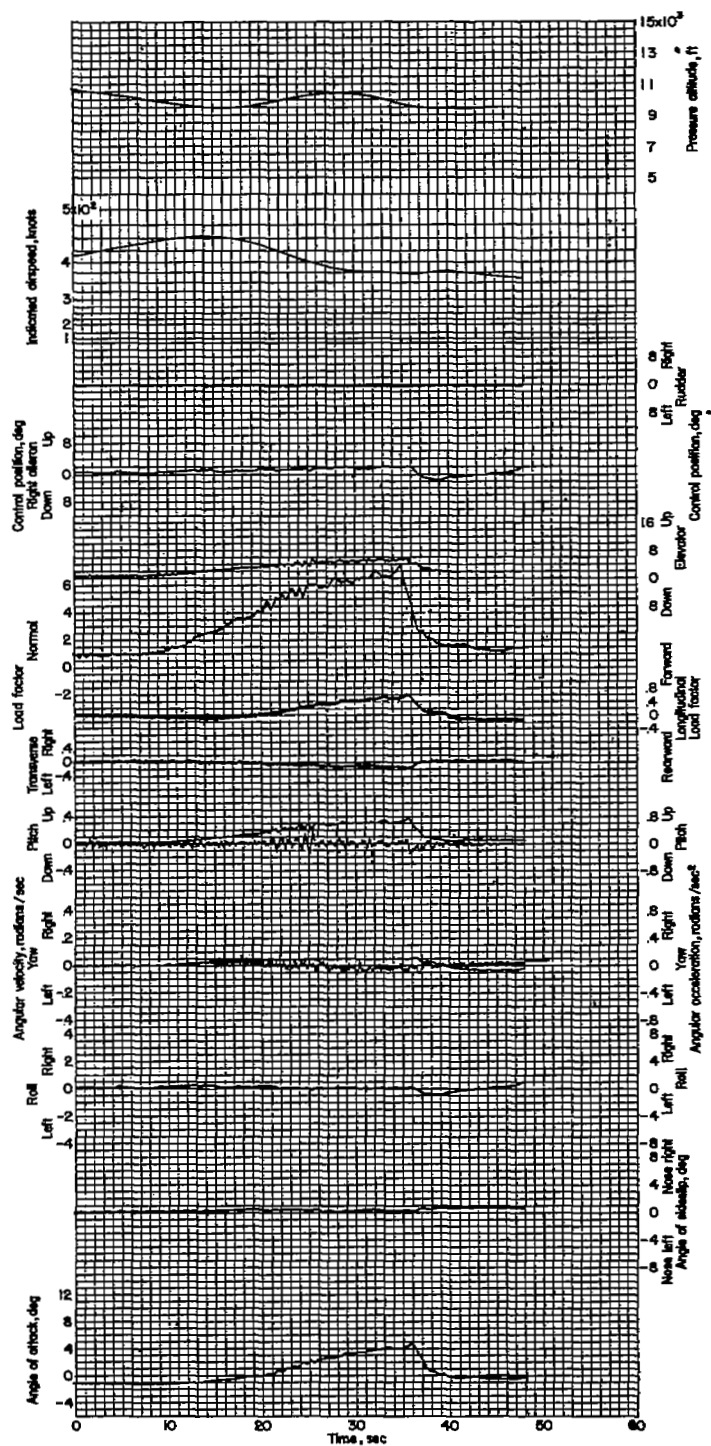


Figure 23.- Right turn. Pilot B; airplane weight, 11,760 pounds; center of gravity at 26.4 percent M.A.C.



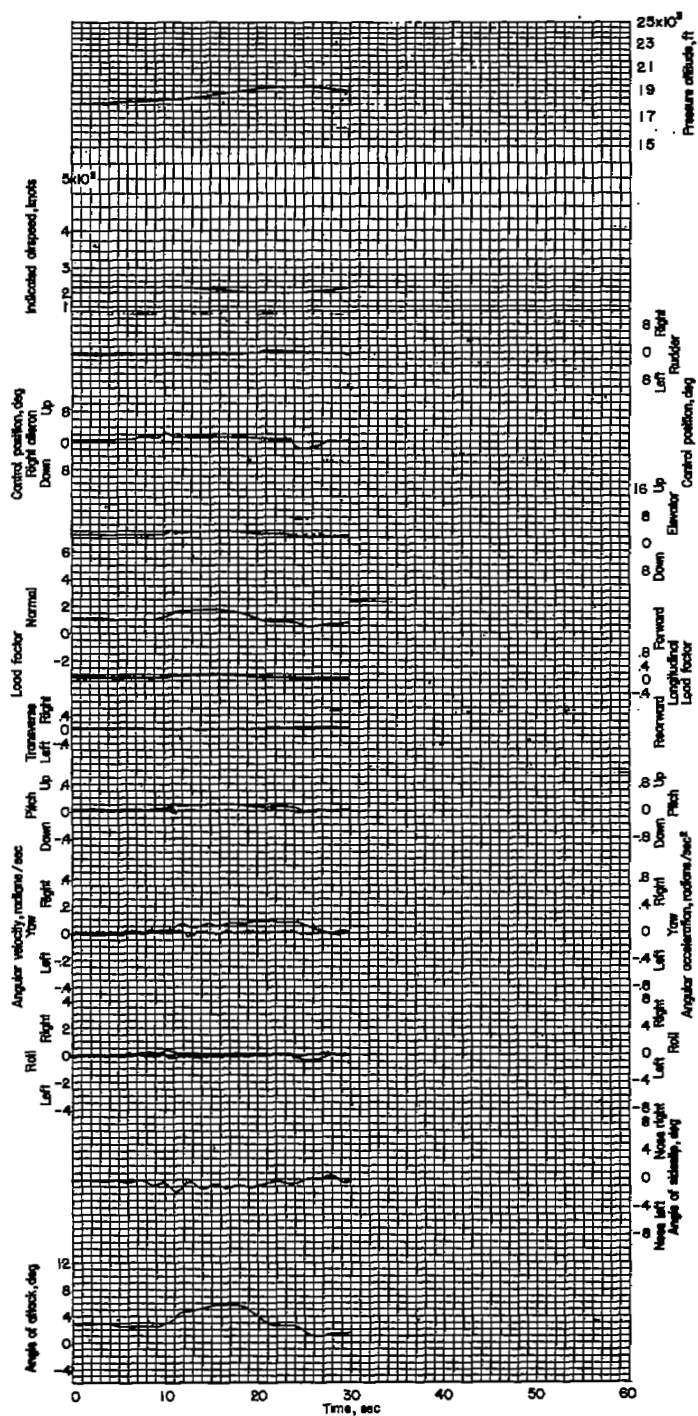


Figure 24.- Right turn. Pilot E wearing anti-gravity suit; airplane weight, 12,490 pounds; center of gravity at 27.8 percent M.A.C.

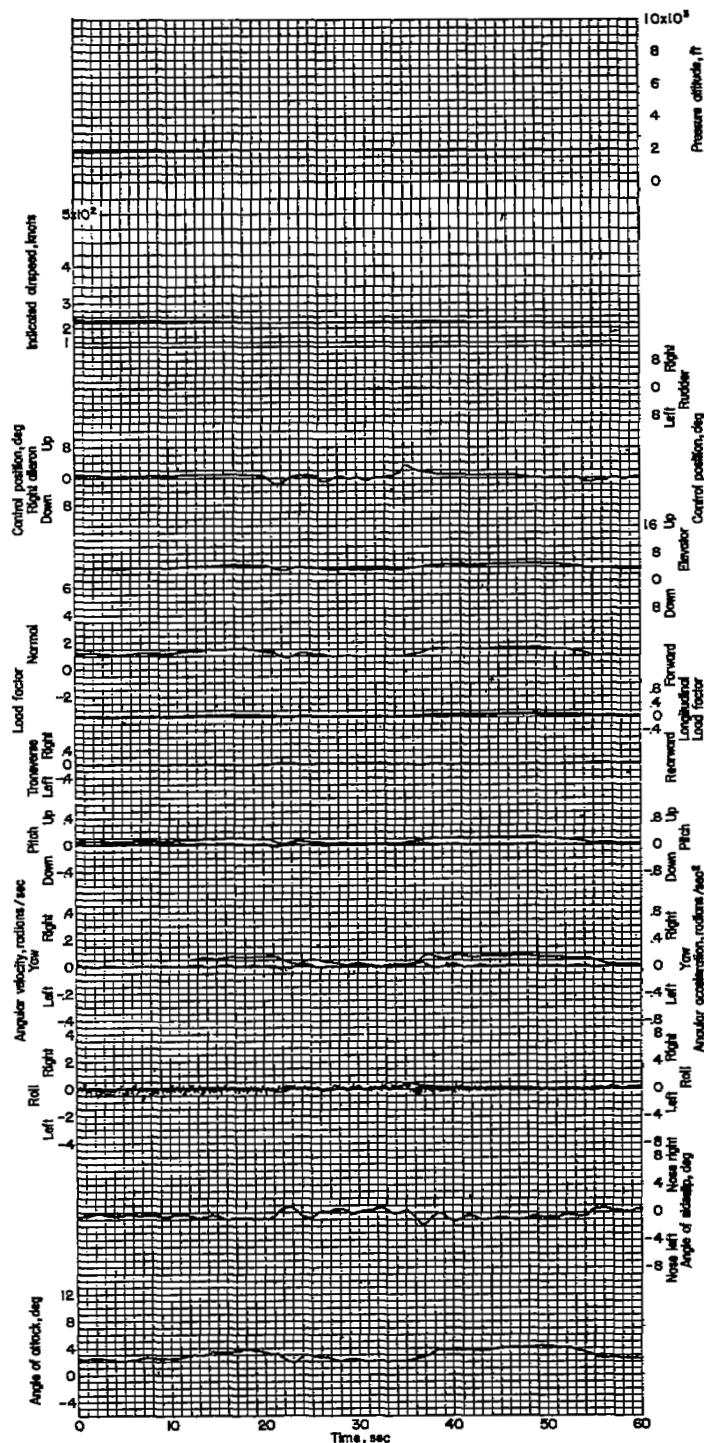


Figure 25.- Right turns. Pilot E wearing anti-gravity suit and with radar observer; tip tanks on; airplane weight, 14,300 pounds; center of gravity at 27.4 percent M.A.C.

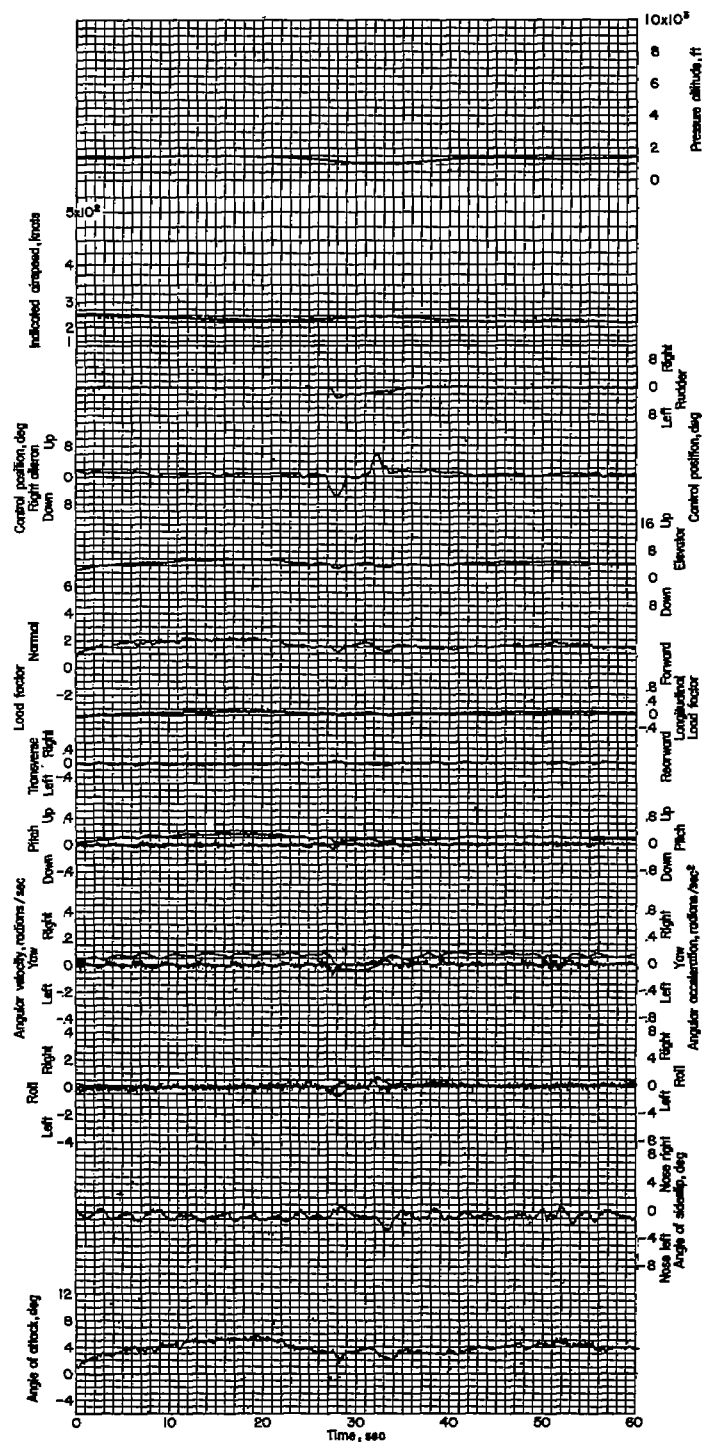


Figure 26.- Right turns. Pilot E wearing anti-gravity suit and with radar observer; tip tanks on; airplane weight, 14,700 pounds; center of gravity at 27.6 percent M.A.C.



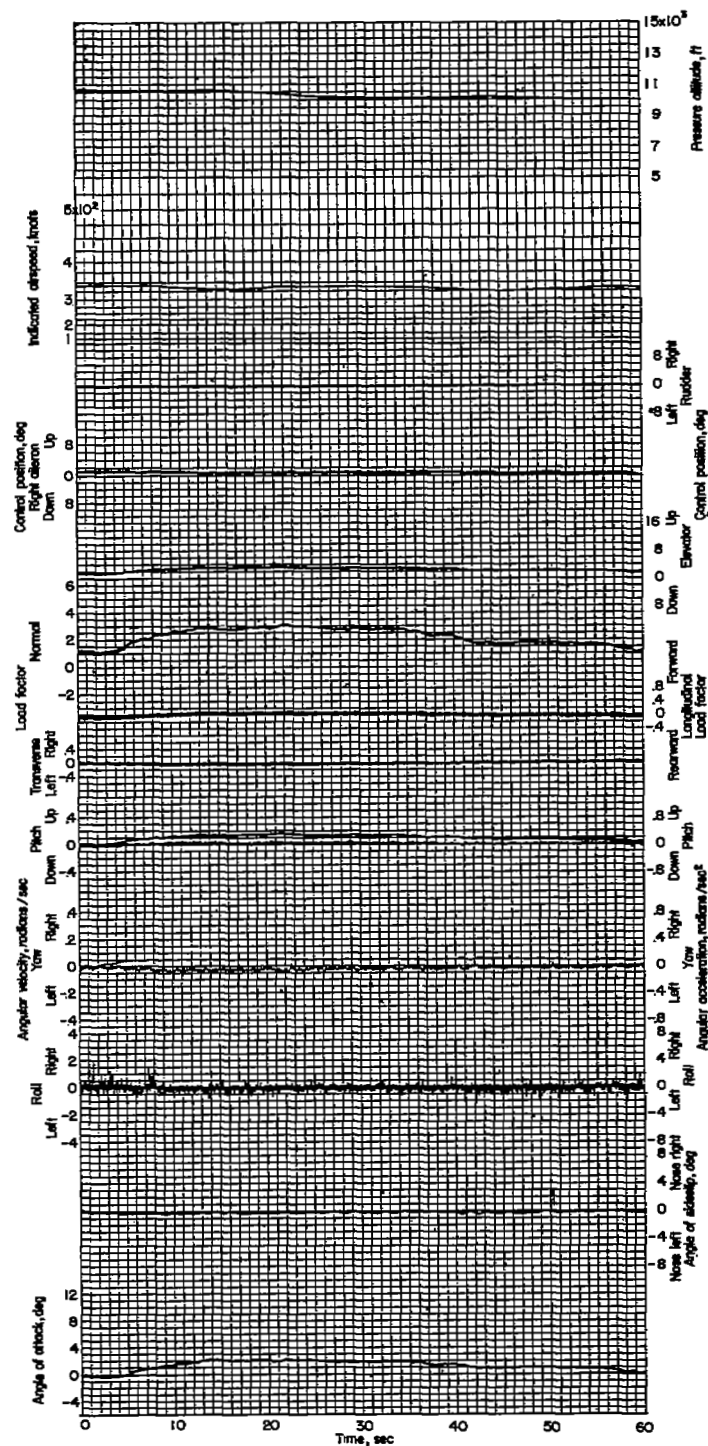


Figure 27.- Right turn. Pilot F wearing anti-gravity suit and with radar observer; airplane weight, 12,080 pounds; center of gravity at 25.7 percent M.A.C.

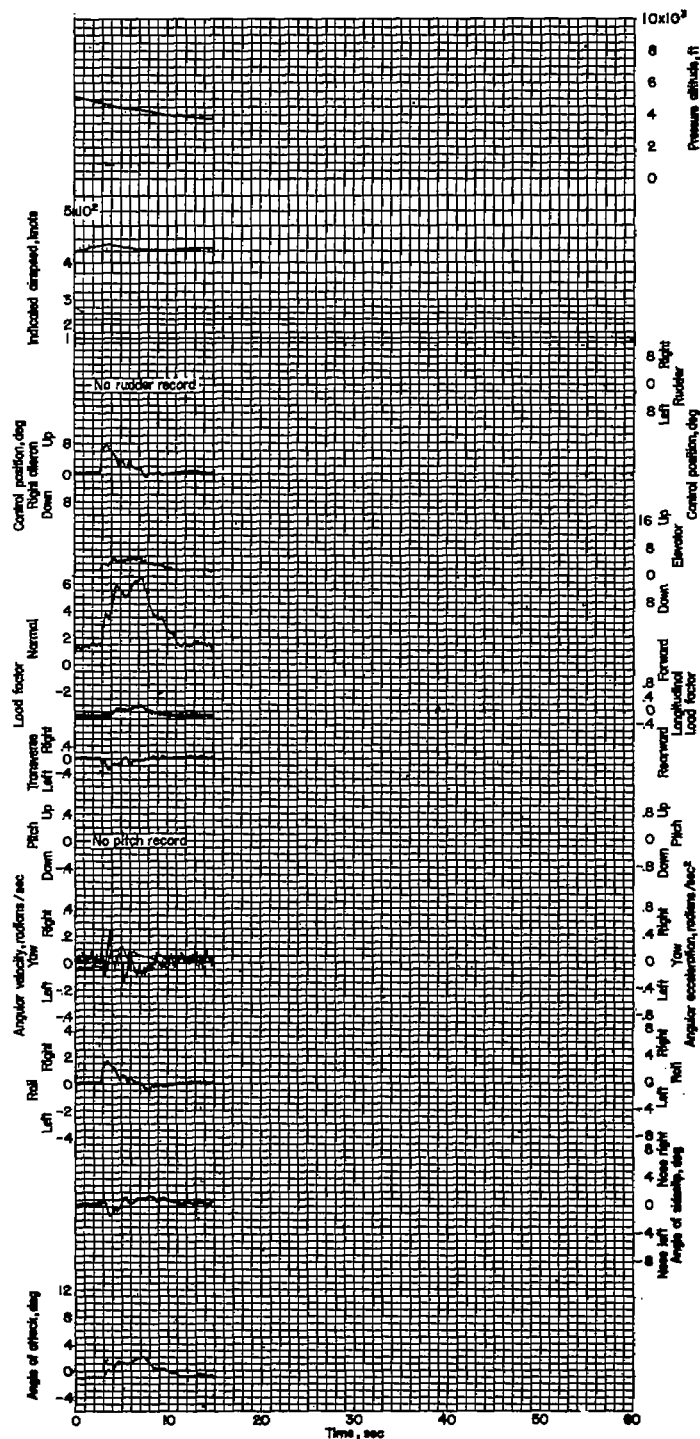


Figure 28.- Right turn. Pilot G with radar observer; airplane weight, 12,565 pounds; center of gravity at 26.7 percent M.A.C.

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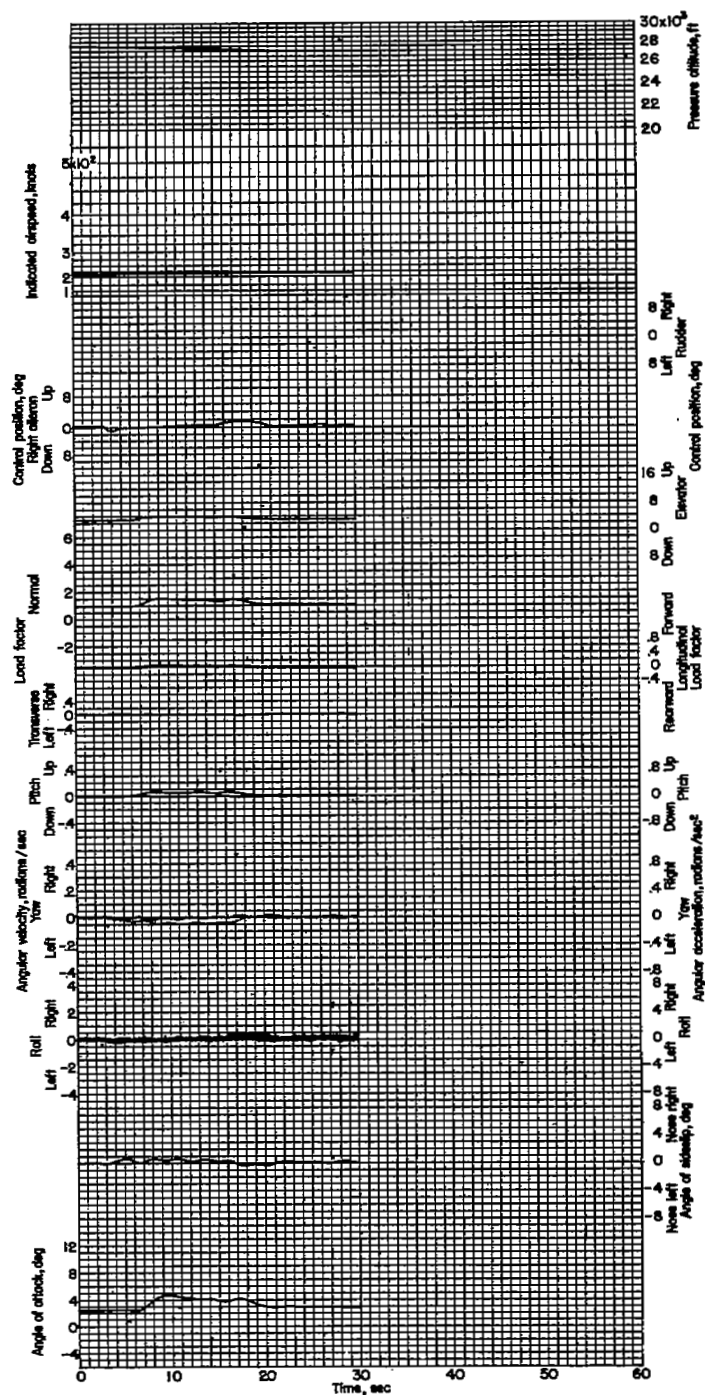


Figure 29.- Left turn. Pilot B; airplane weight, 12,220 pounds; center of gravity at 27.3 percent M.A.C.



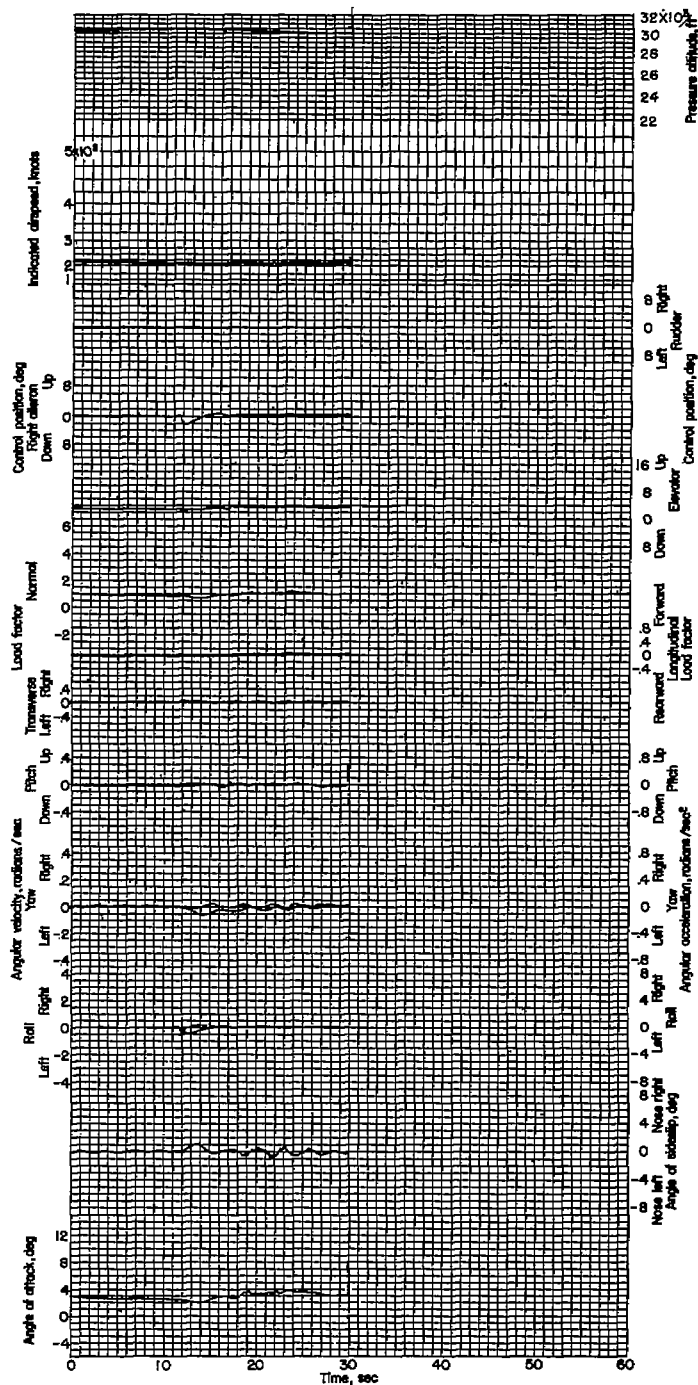


Figure 30.- Left turn. Pilot B with radar observer; airplane weight, 12,265 pounds; center of gravity at 26.1 percent M.A.C.

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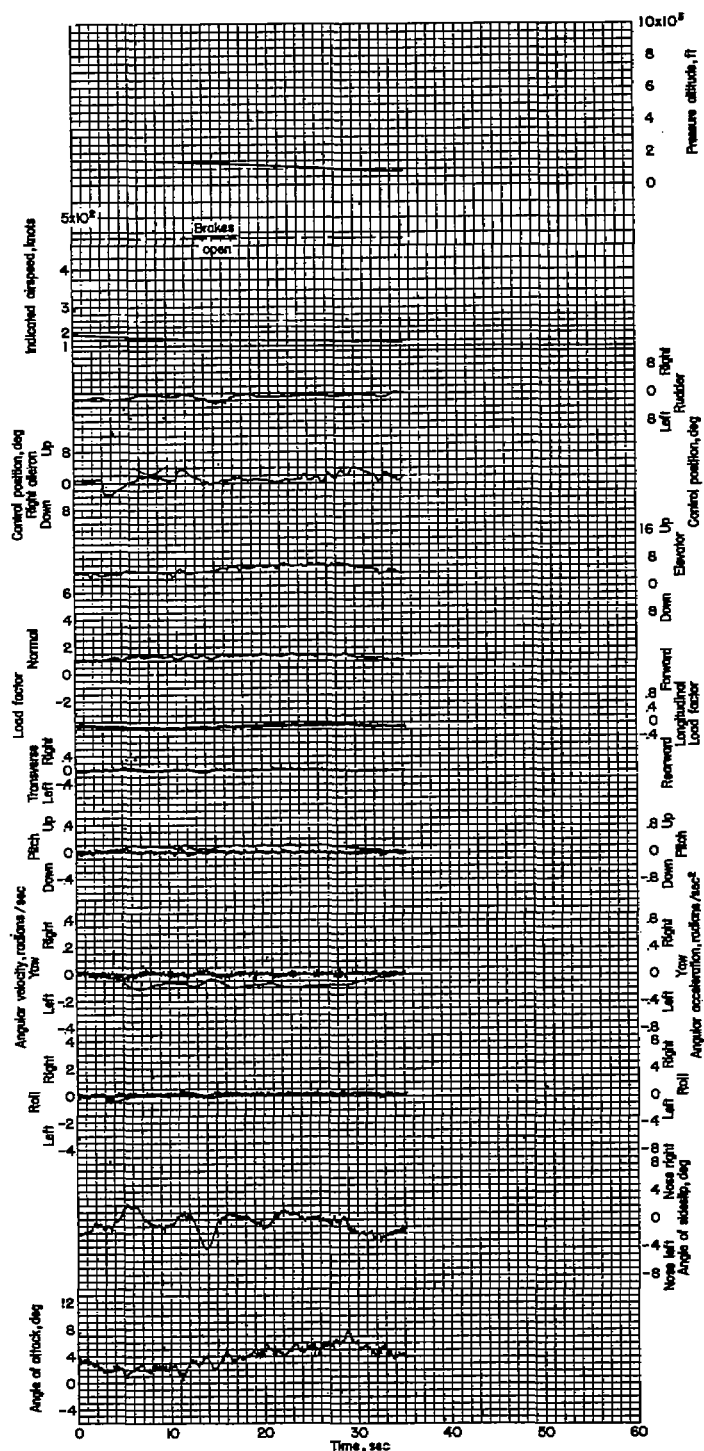


Figure 31.- Left turns. Pilot E wearing anti-gravity suit and with radar observer; tip tanks on; airplane weight, 13,750 pounds; center of gravity at 27.1 percent M.A.C.

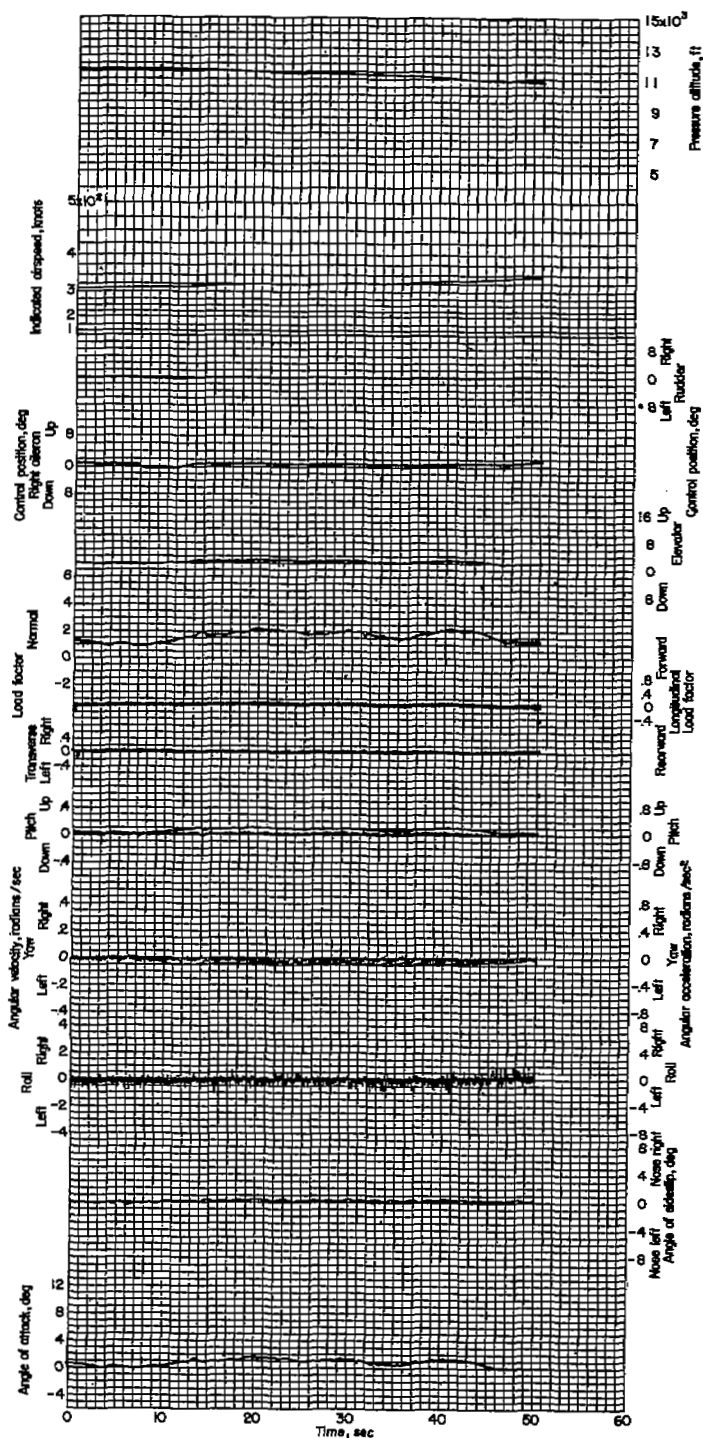


Figure 32.- Left turn. Pilot F wearing anti-gravity suit and with radar observer; airplane weight, 12,130 pounds; center of gravity at 25.8 percent M.A.C.

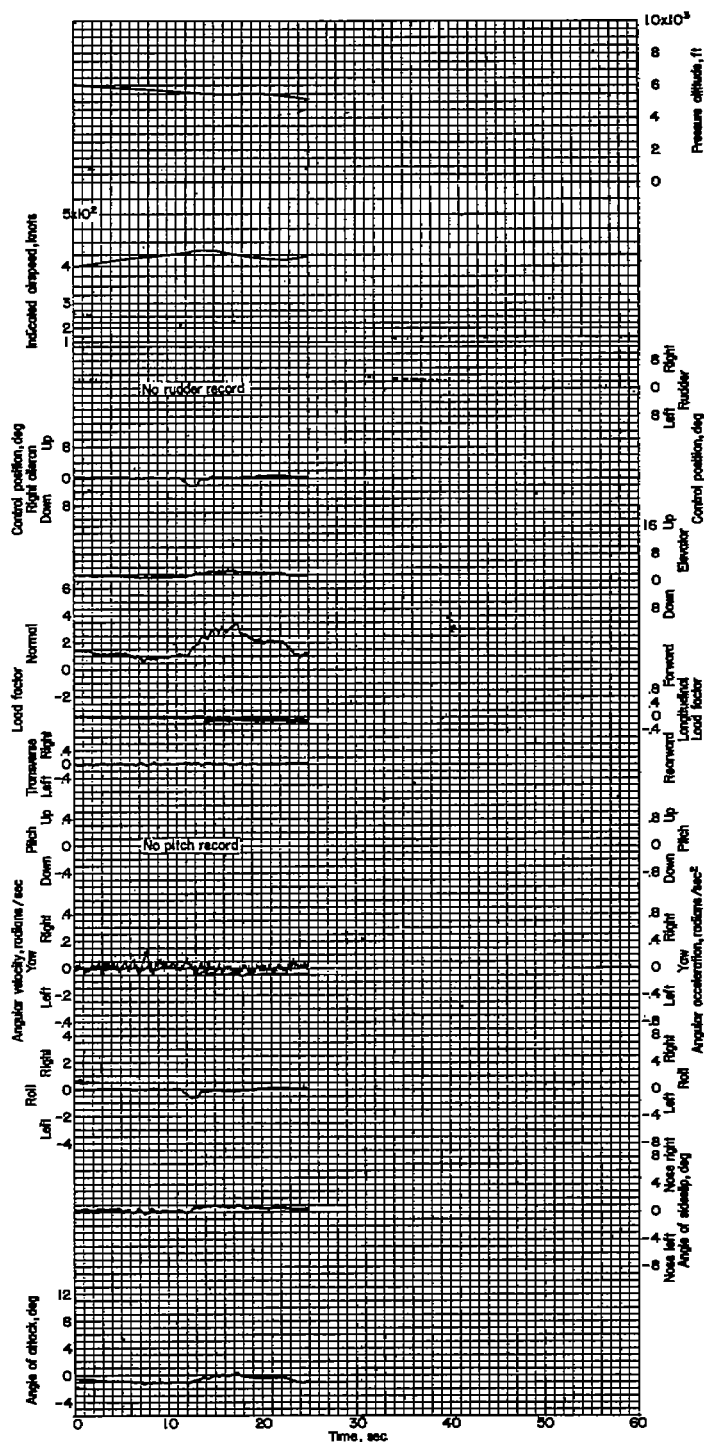


Figure 33.- Left turn. Pilot G with radar observer; airplane weight, 12,590 pounds; center of gravity at 26.7 percent M.A.C.

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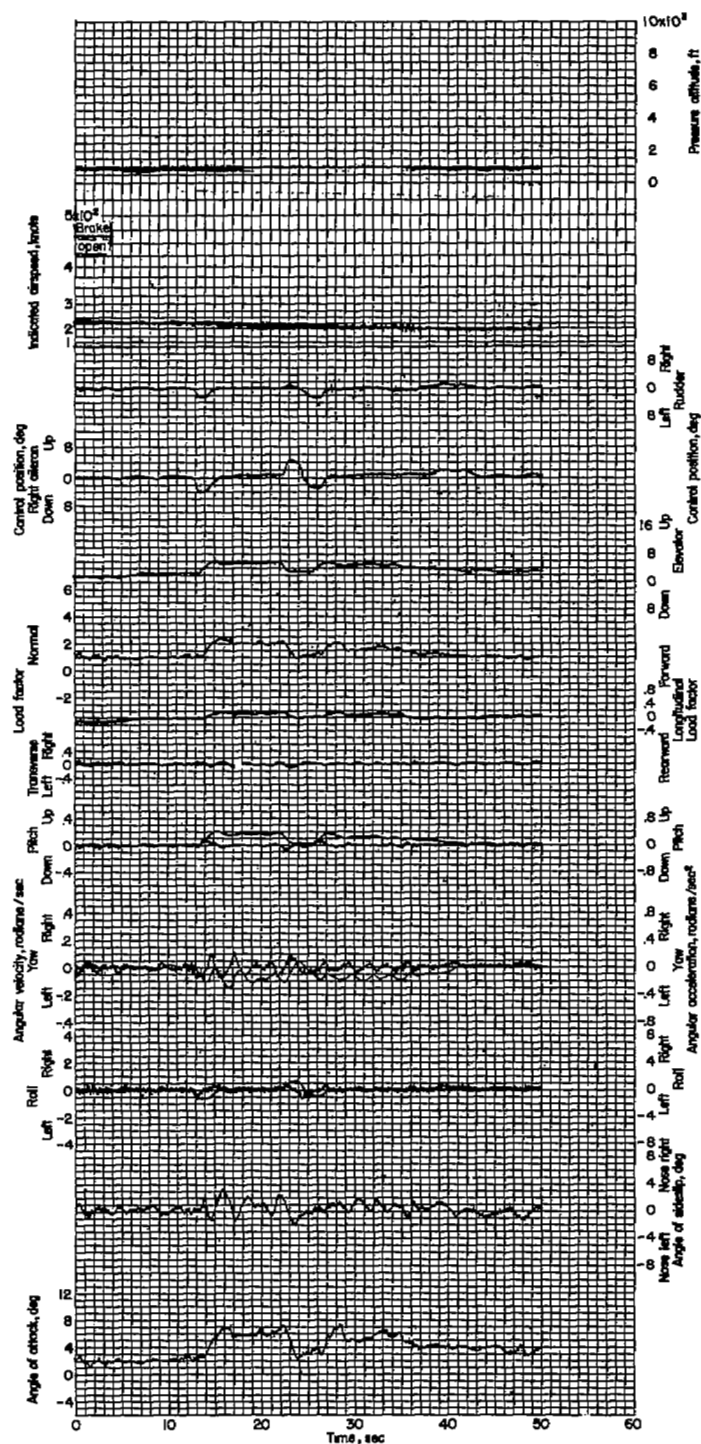


Figure 34.- Two left turns. Pilot A; airplane weight, 11,425 pounds; center of gravity at 25.8 percent M.A.C.



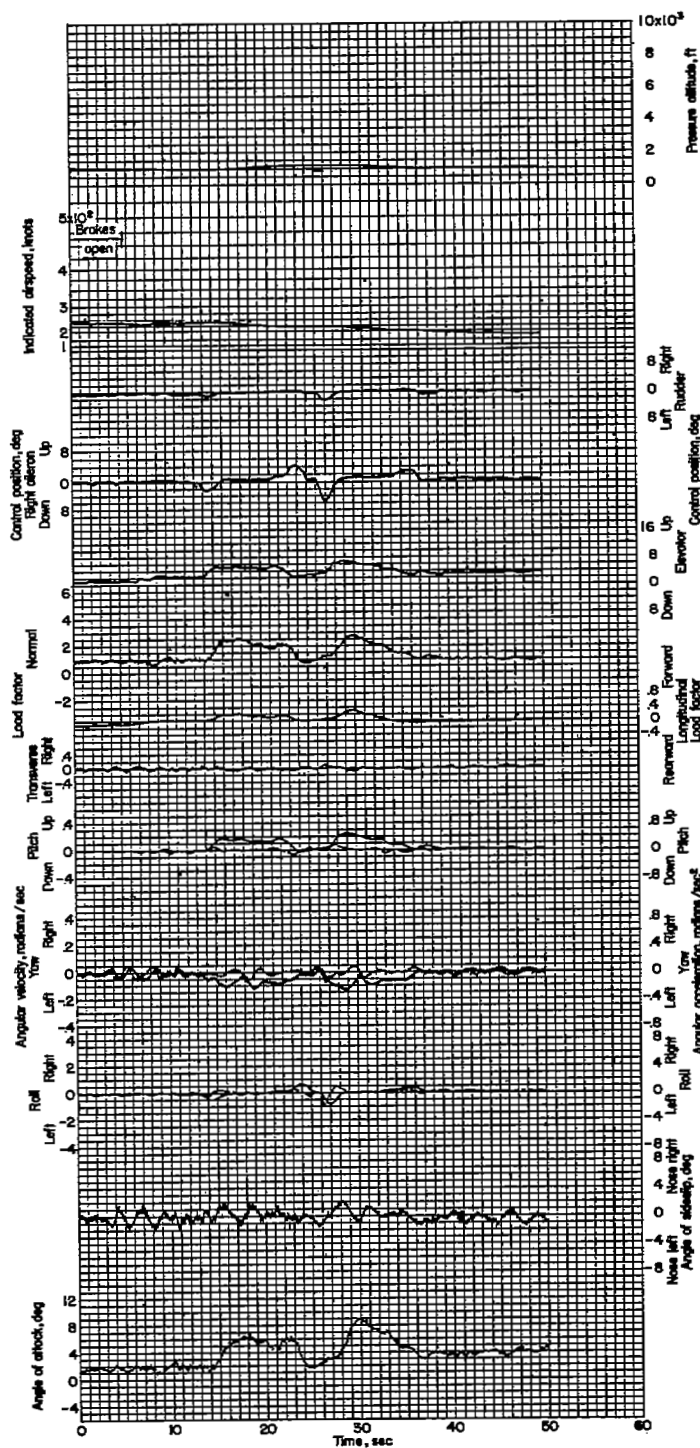


Figure 35.- Two left turns. Pilot A; airplane weight, 11,860 pounds; center of gravity at 26.6 percent M.A.C.

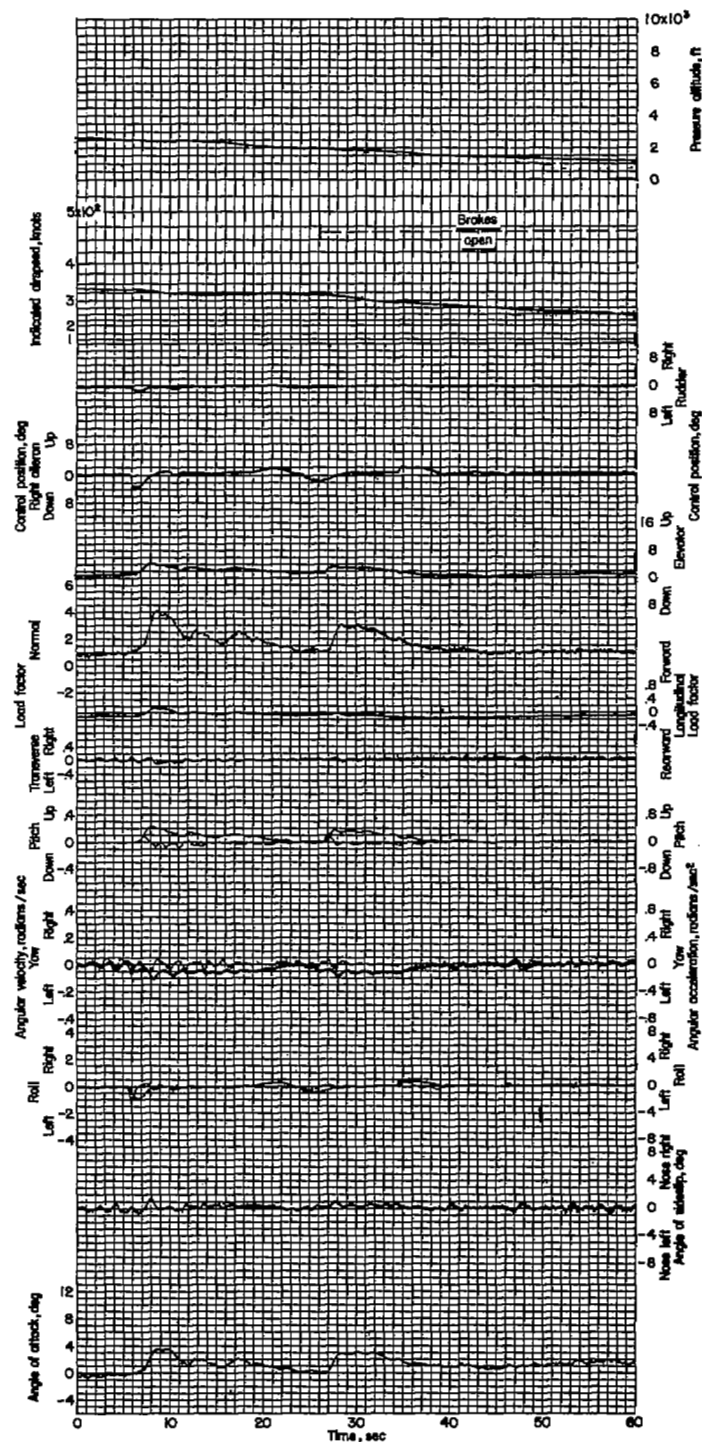


Figure 36.- Two left turns. Pilot A; airplane weight, 11,895 pounds; center of gravity at 26.7 percent M.A.C.

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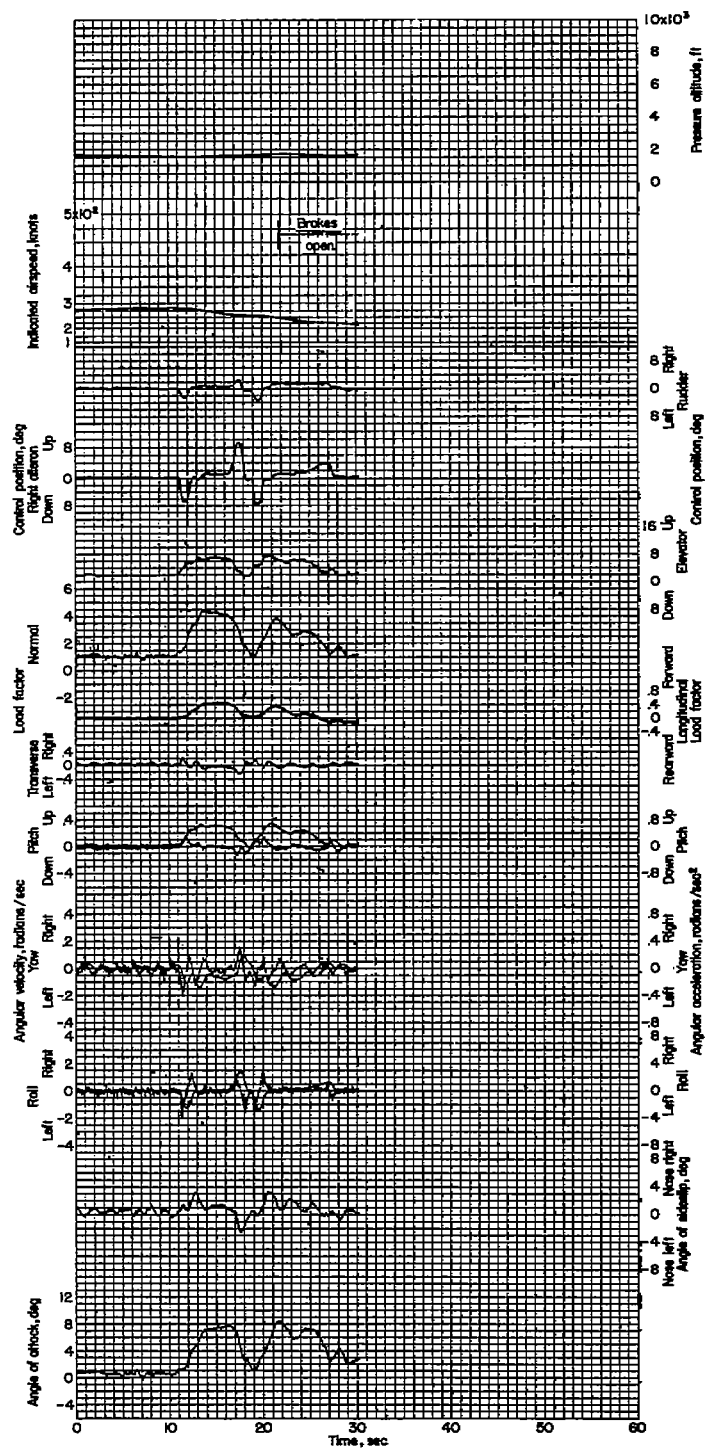


Figure 37.- Two left turns. Pilot A wearing anti-gravity suit; airplane weight, 11,620 pounds; center of gravity at 26.1 percent M.A.C.

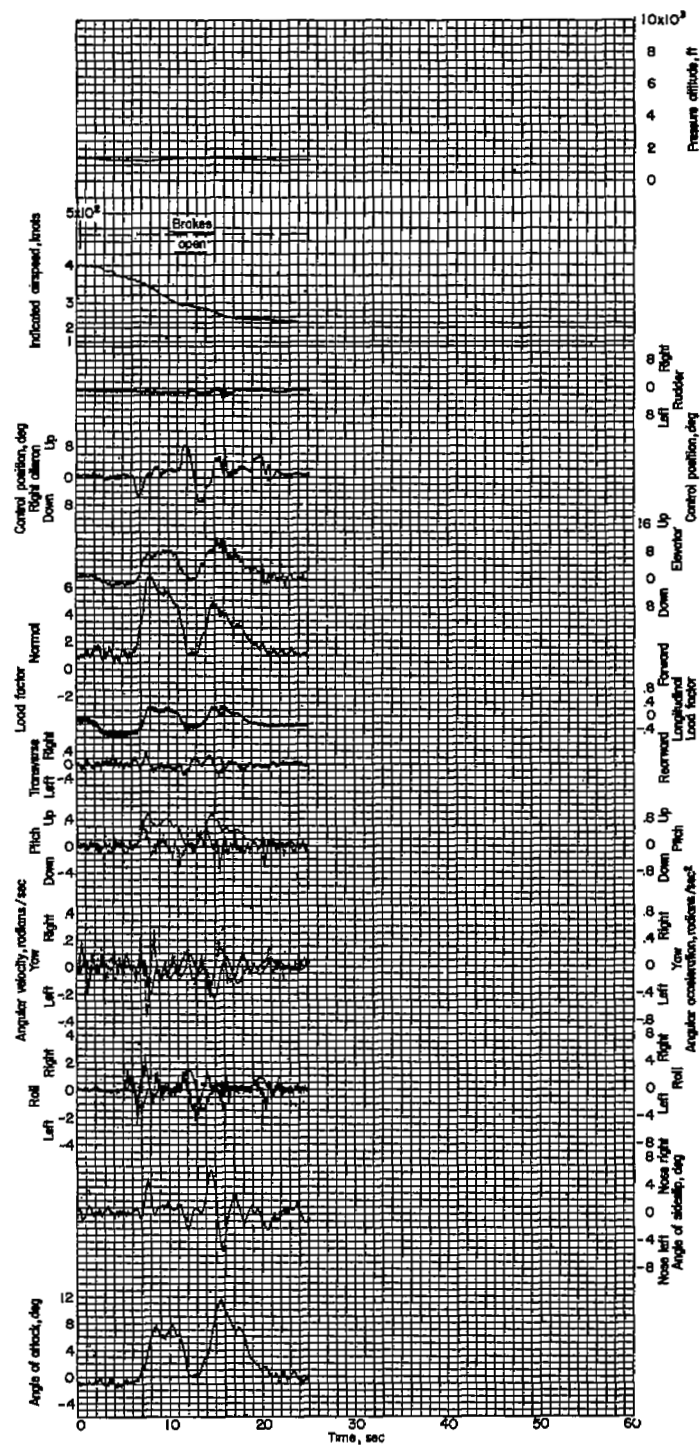
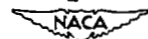


Figure 38.- Two left turns. Pilot B; airplane weight, 11,625 pounds; center of gravity at 26.2 percent M.A.C.



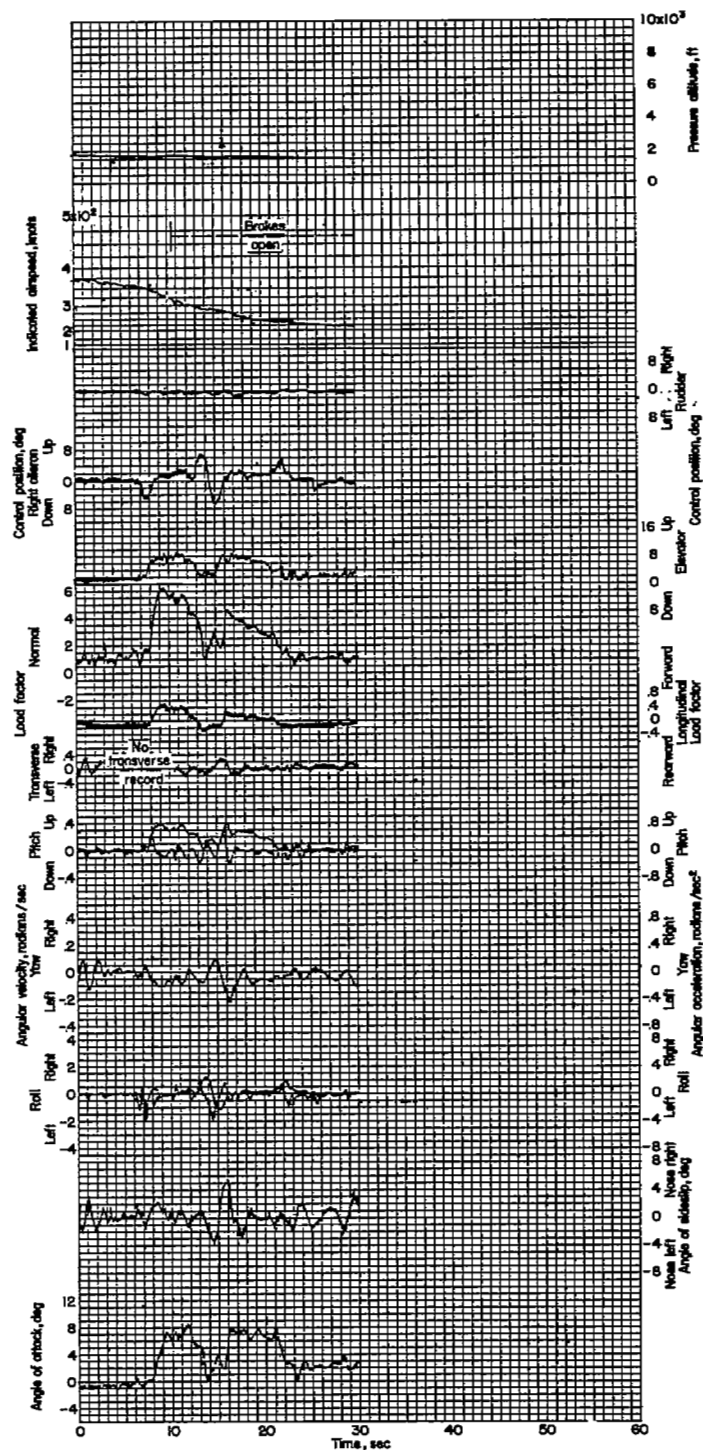


Figure 39.- Two left turns. Pilot B with radar observer; airplane weight, 11,880 pounds; center of gravity at 25.3 percent M.A.C.



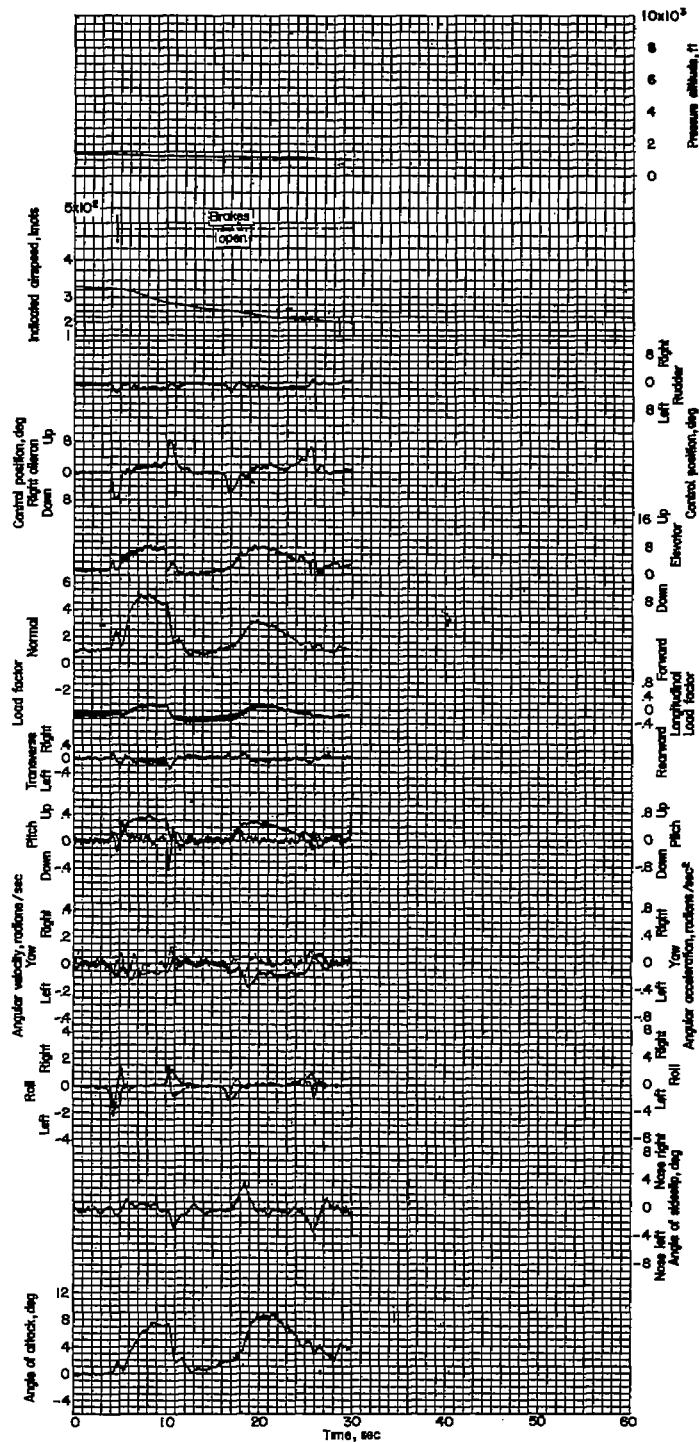


Figure 40.- Two left turns. Pilot C with radar observer; airplane weight, 11,810 pounds; center of gravity at 25.2 percent M.A.C.

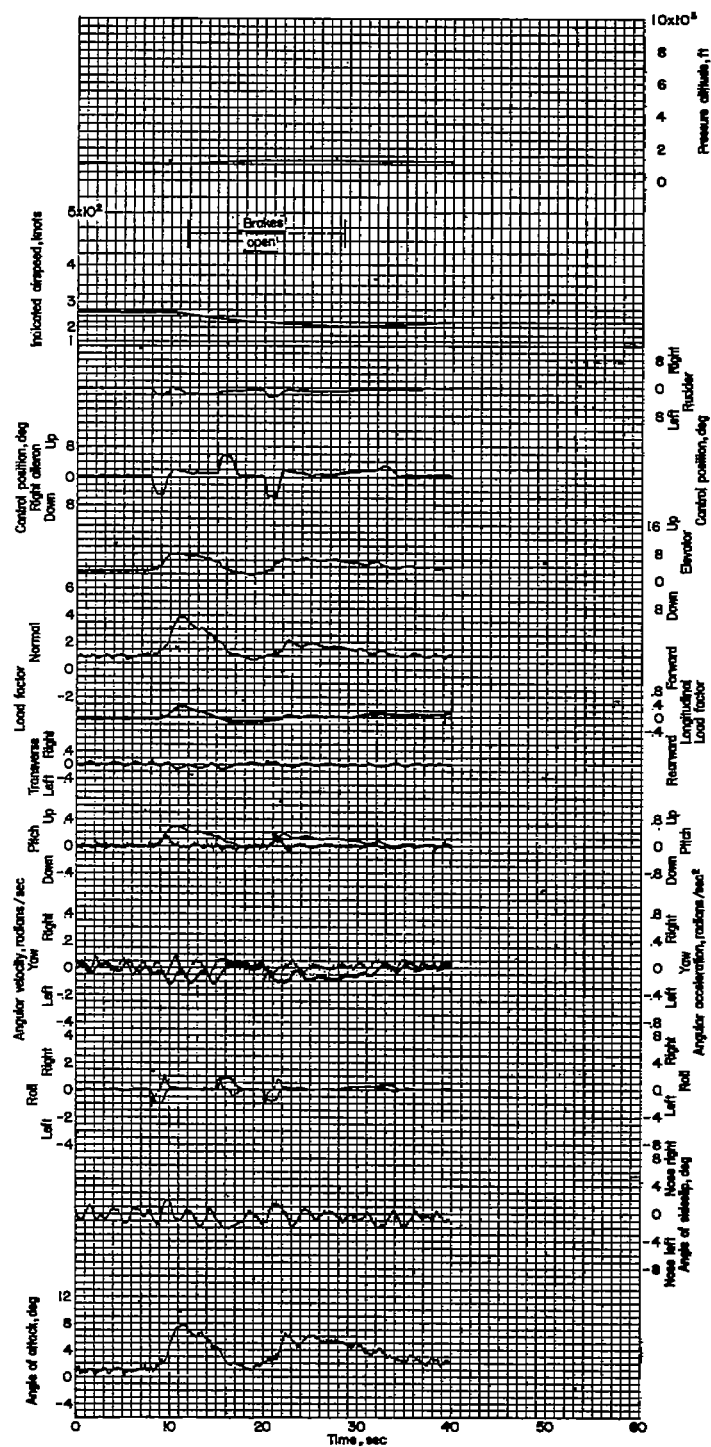


Figure 41.- Two left turns. Pilot D with radar observer; airplane weight, 11,820 pounds; center of gravity at 25.2 percent M.A.C.

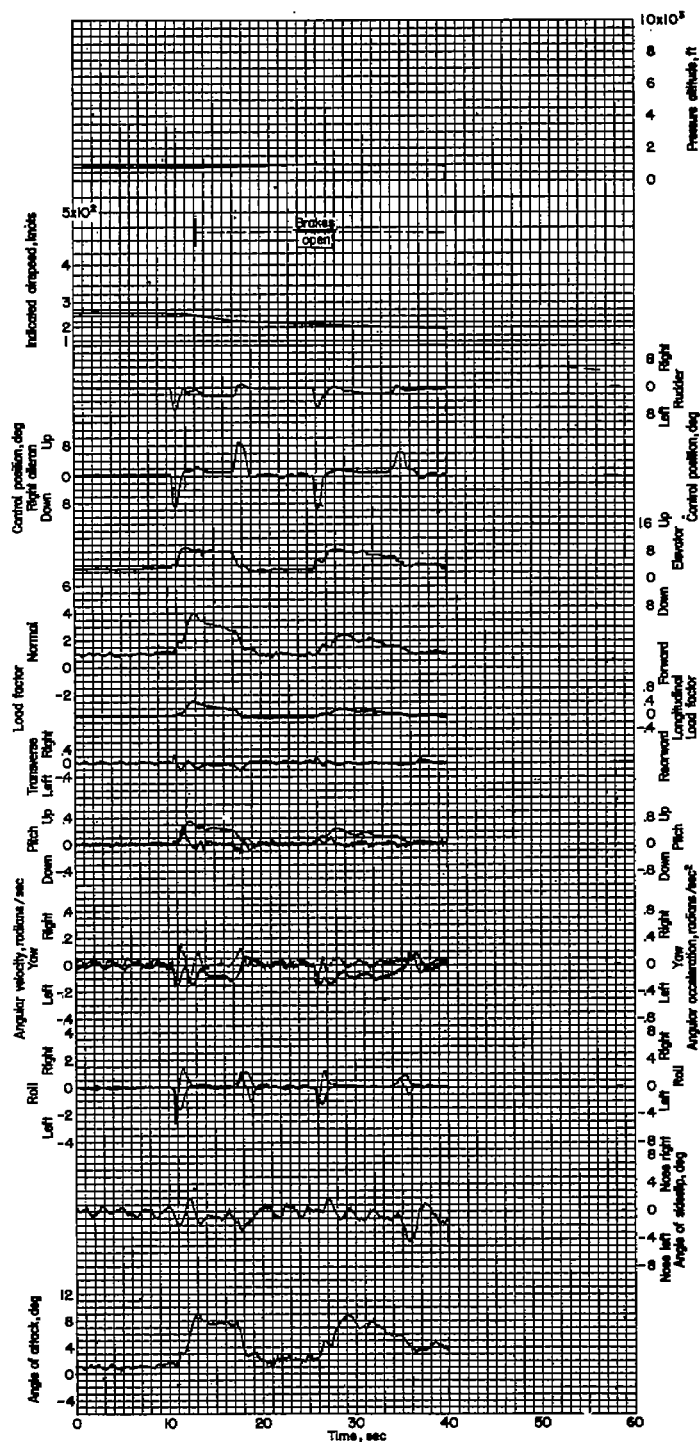


Figure 42.- Two left turns. Pilot D with radar observer; airplane weight, 12,055 pounds; center of gravity at 25.7 percent M.A.C.

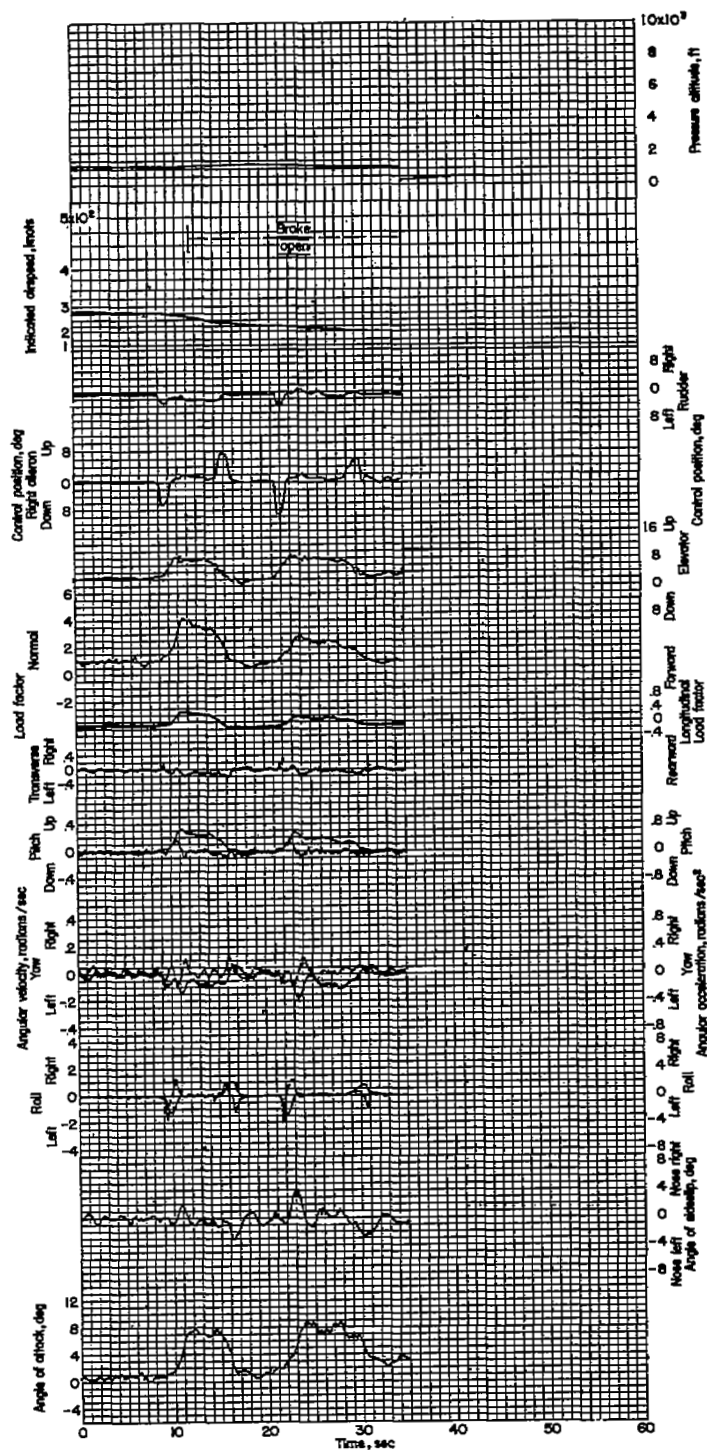


Figure 43.- Two left turns. Pilot D with radar observer; airplane weight, 11,775 pounds; center of gravity at 25.1 percent M.A.C.

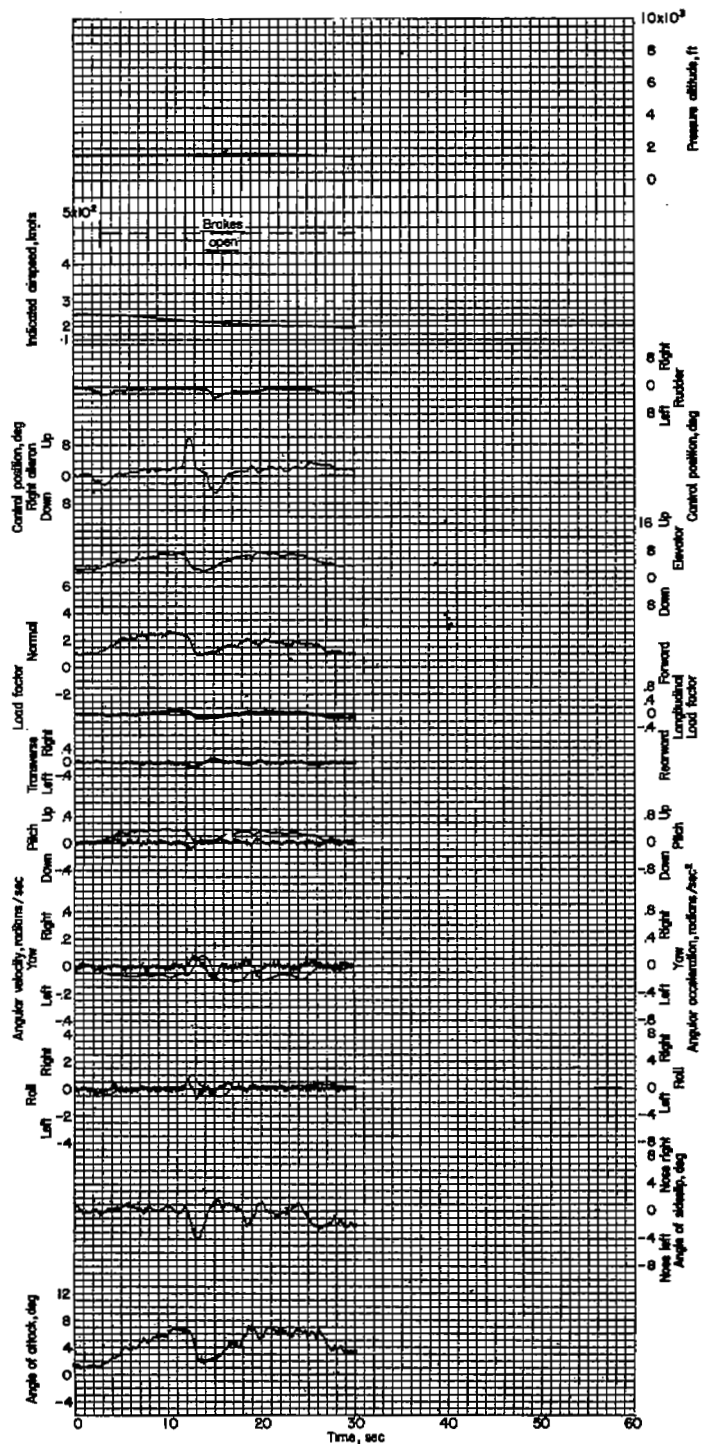


Figure 44.- Two left turns. Pilot E wearing anti-gravity suit and with radar observer; tip tanks on; airplane weight, 13,760 pounds; center of gravity at 27.2 percent M.A.C.

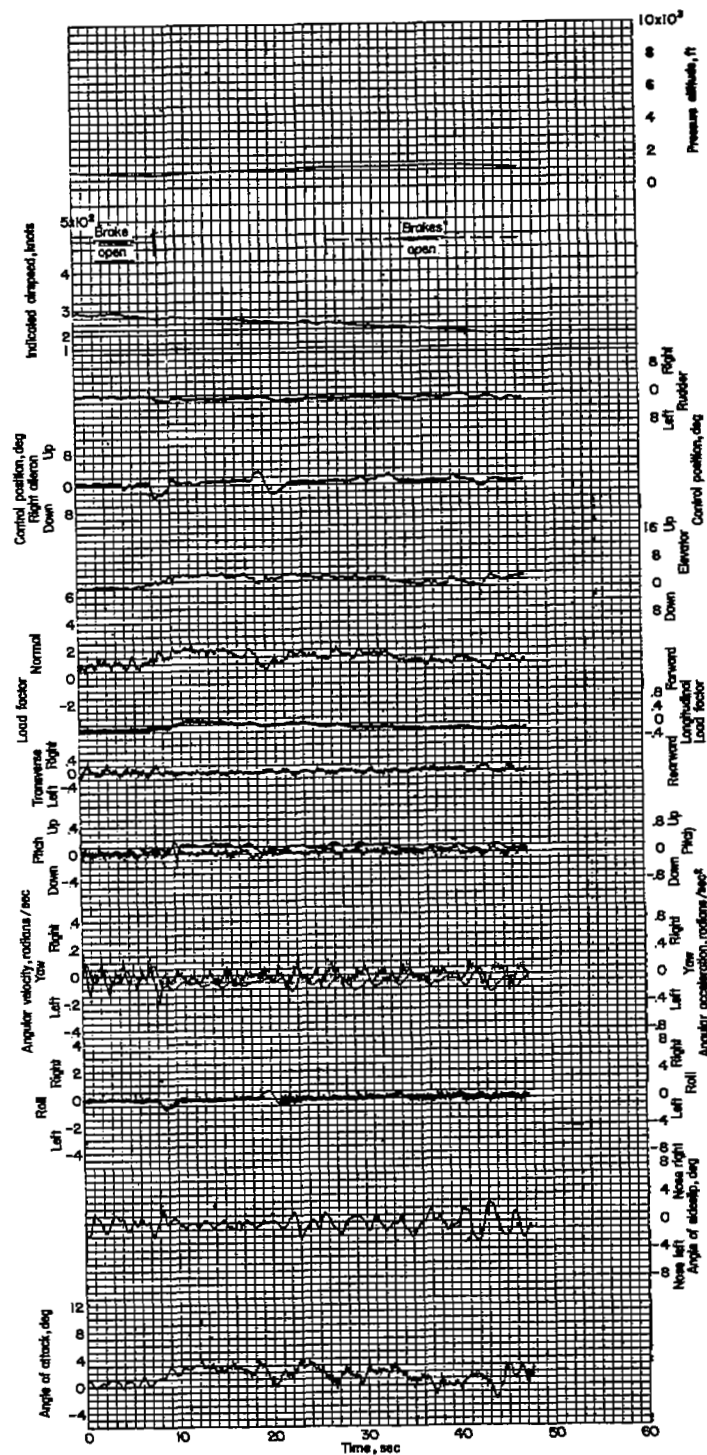


Figure 45.- Two left turns. Pilot F wearing anti-gravity suit and with radar observer; airplane weight, 11,910 pounds; center of gravity at 25.4 percent M.A.C.

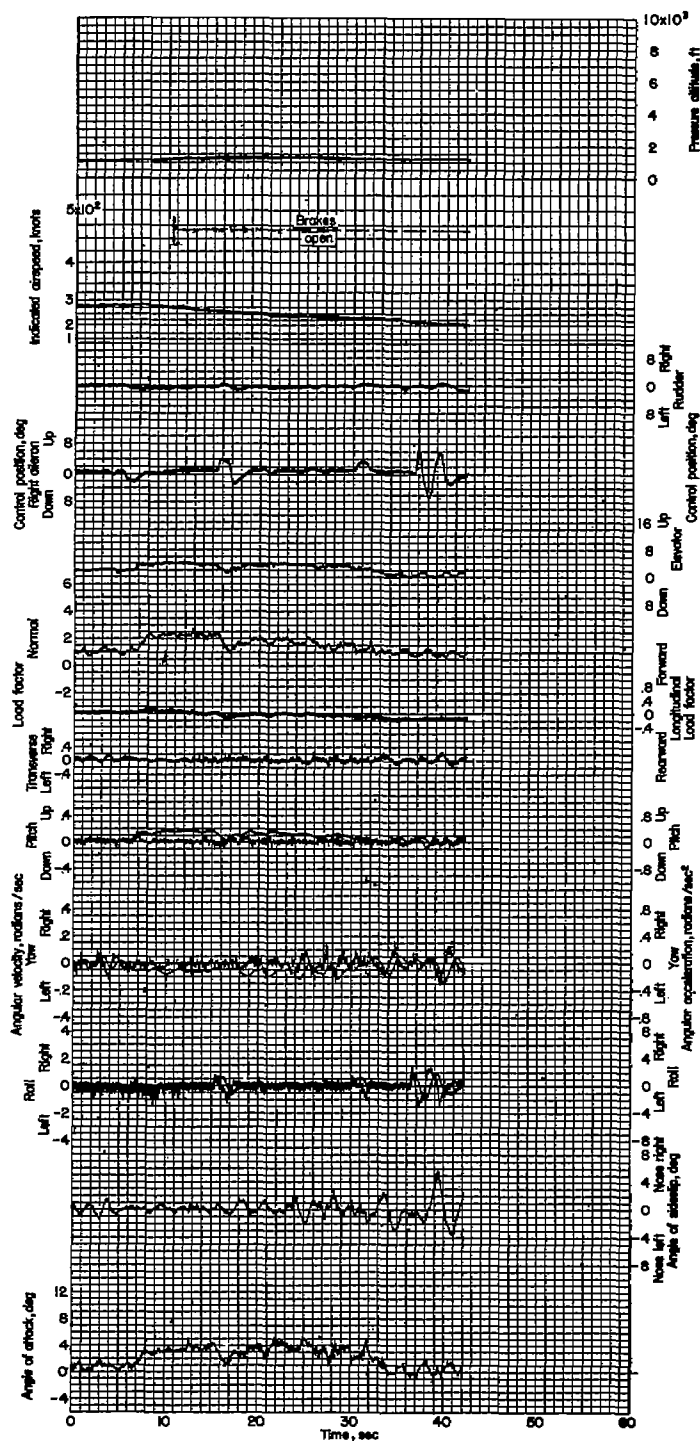


Figure 46.- Two left turns. Pilot F wearing anti-gravity suit and with radar observer; airplane weight, 12,060 pounds; center of gravity at 25.7 percent M.A.C.

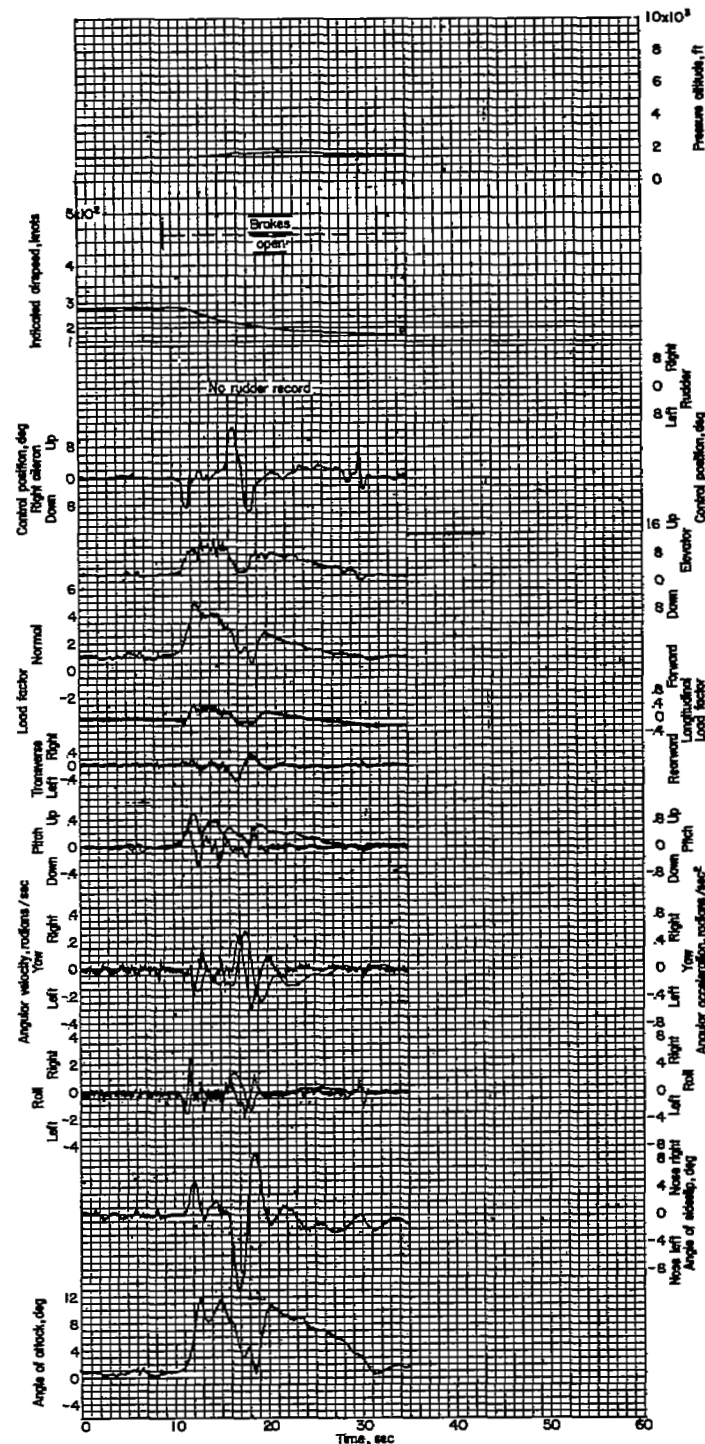


Figure 47.- Two left turns. Pilot G; airplane weight, 11,510 pounds; center of gravity at 25.9 percent M.A.C.

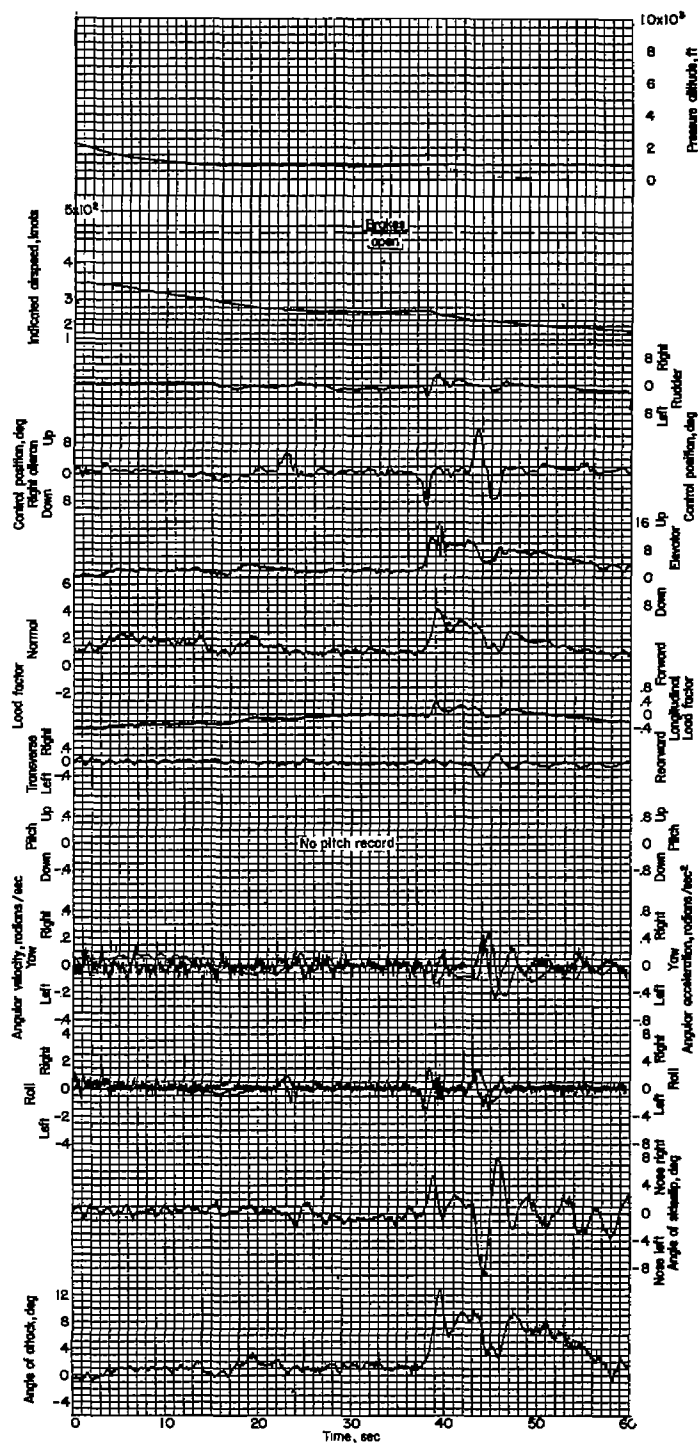


Figure 48.- Two left turns. Pilot G with radar observer; airplane weight, 12,100 pounds; center of gravity at 25.8 percent M.A.C.

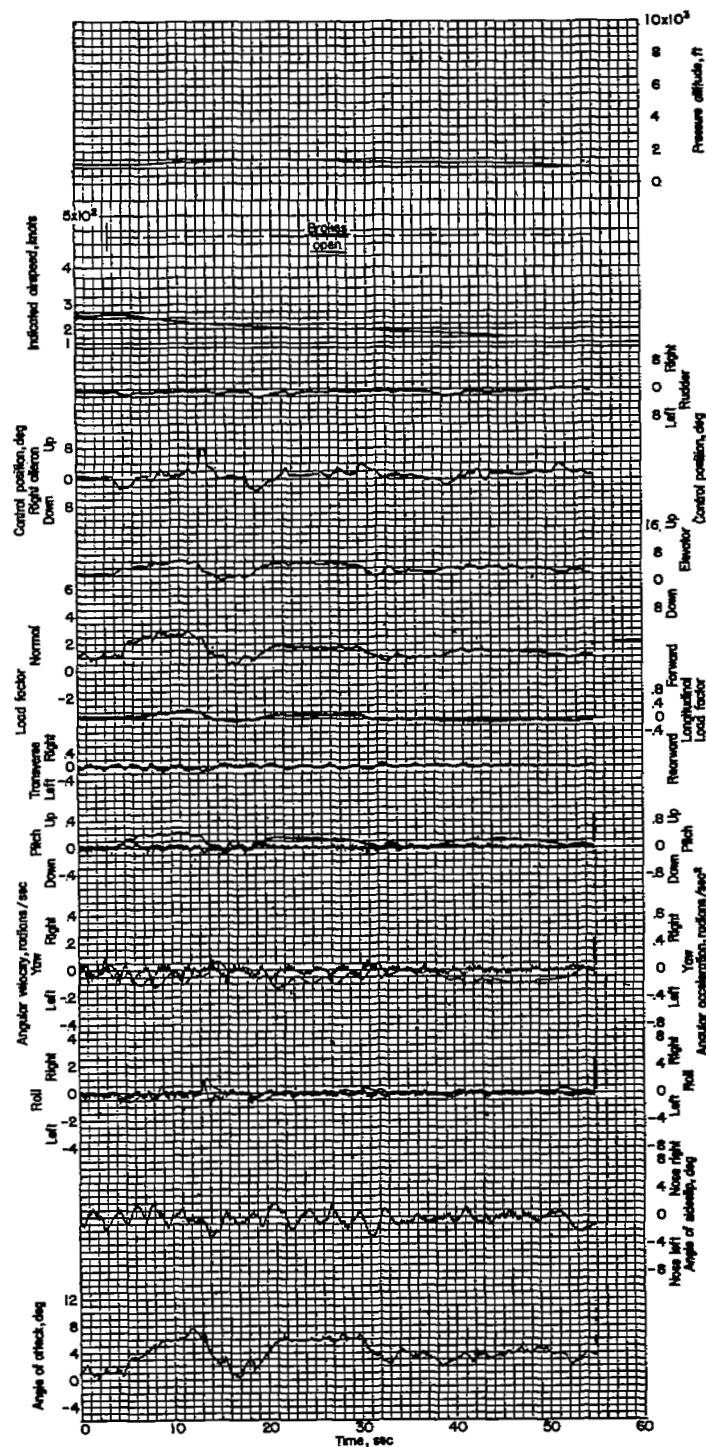


Figure 49.- Three left turns. Pilot E wearing anti-gravity suit; airplane weight, 11,480 pounds; center of gravity at 25.9 percent M.A.C.

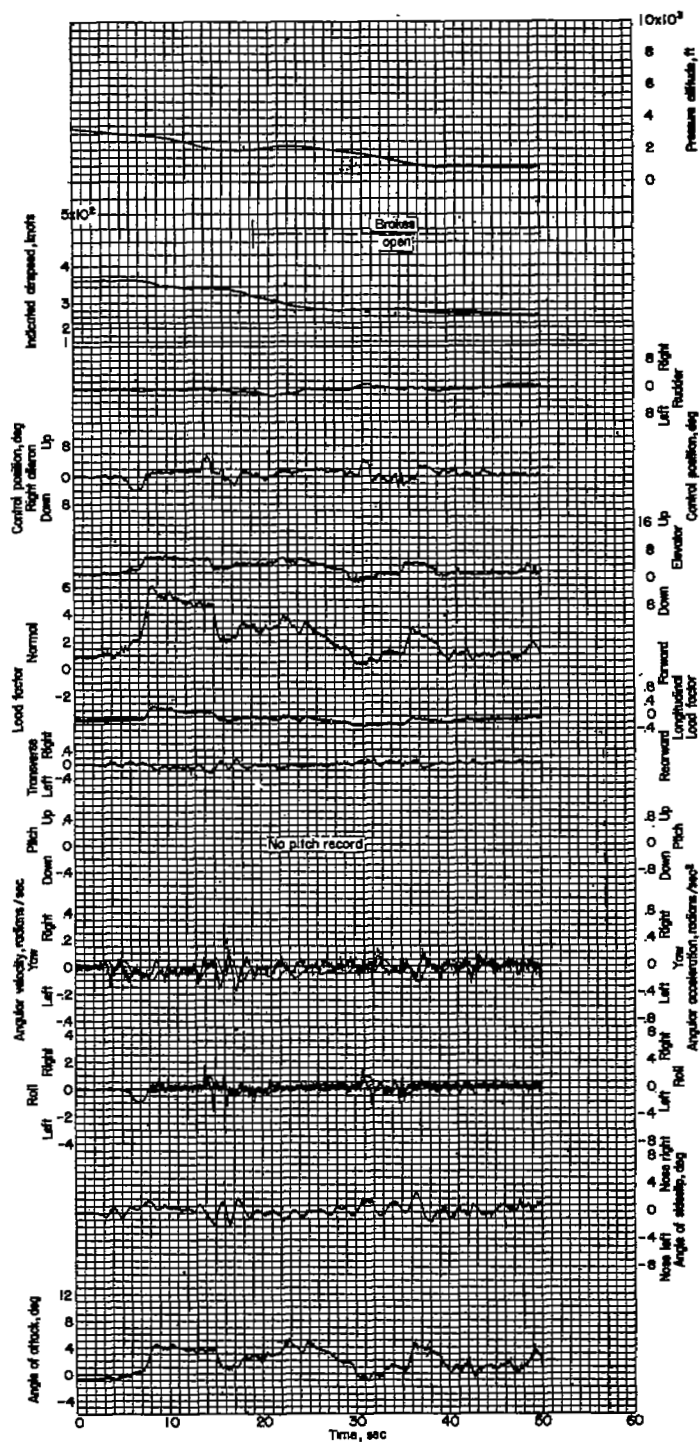


Figure 50.- Three left turns. Pilot G with radar observer; airplane weight, 12,100 pounds; center of gravity at 25.7 percent M.A.C.

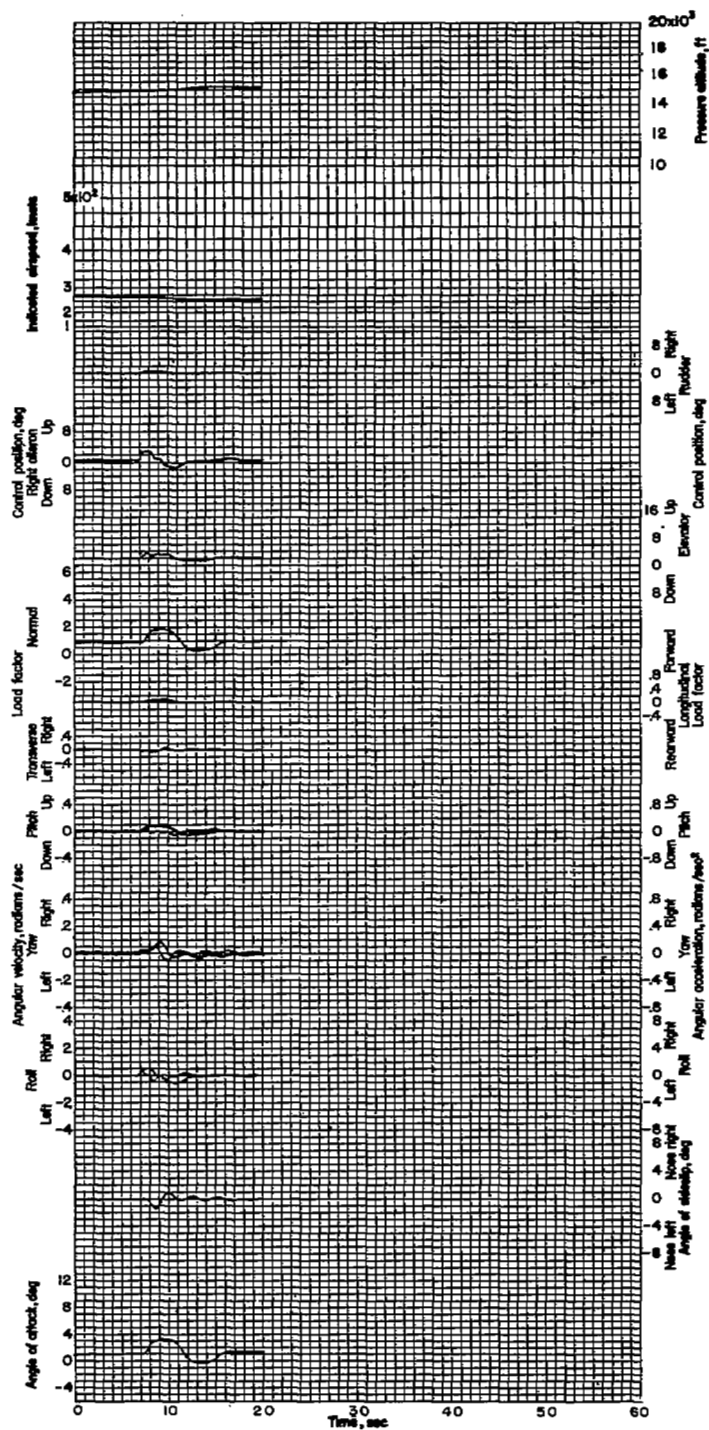


Figure 51.- Right climbing turn. Pilot A; airplane weight, 12,225 pounds; center of gravity at 27.3 percent M.A.C.



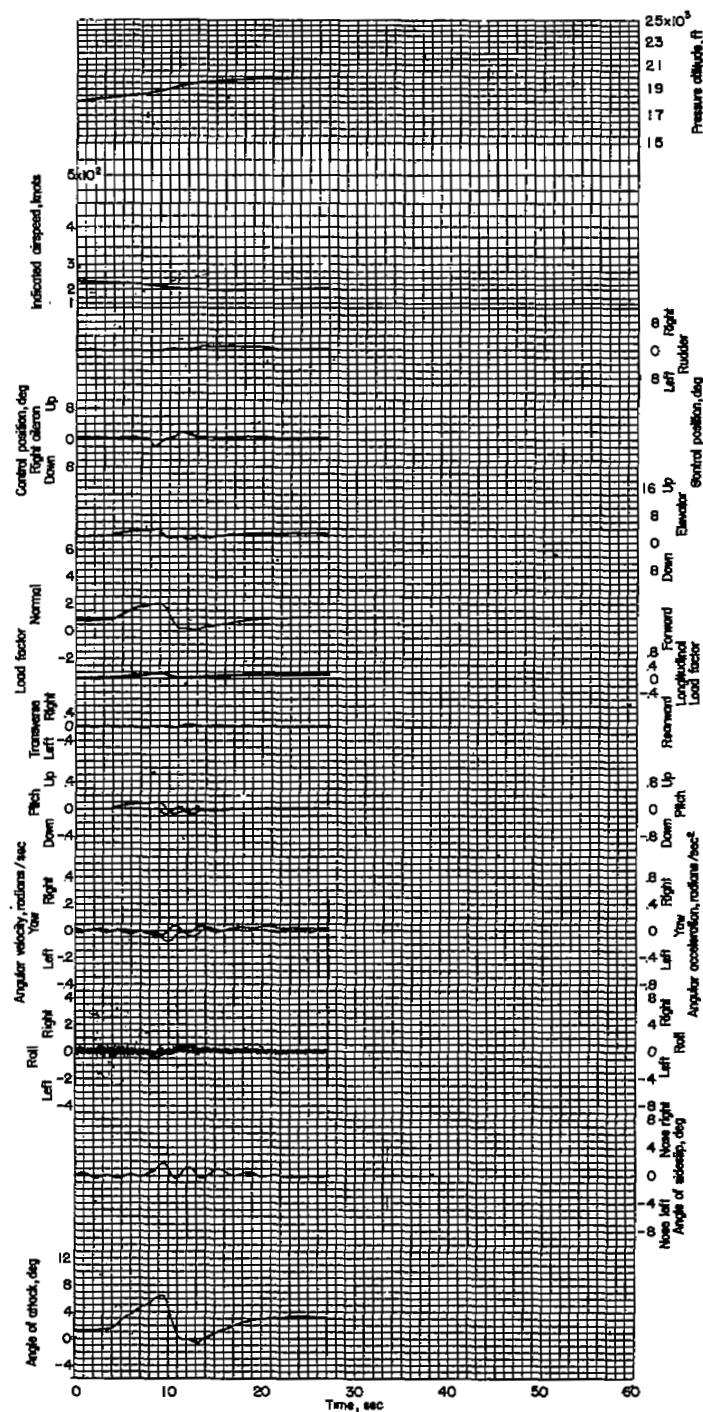


Figure 52.- Left climbing turns. Pilot A; airplane weight, 12,300 pounds; center of gravity at 27.5 percent M.A.C.



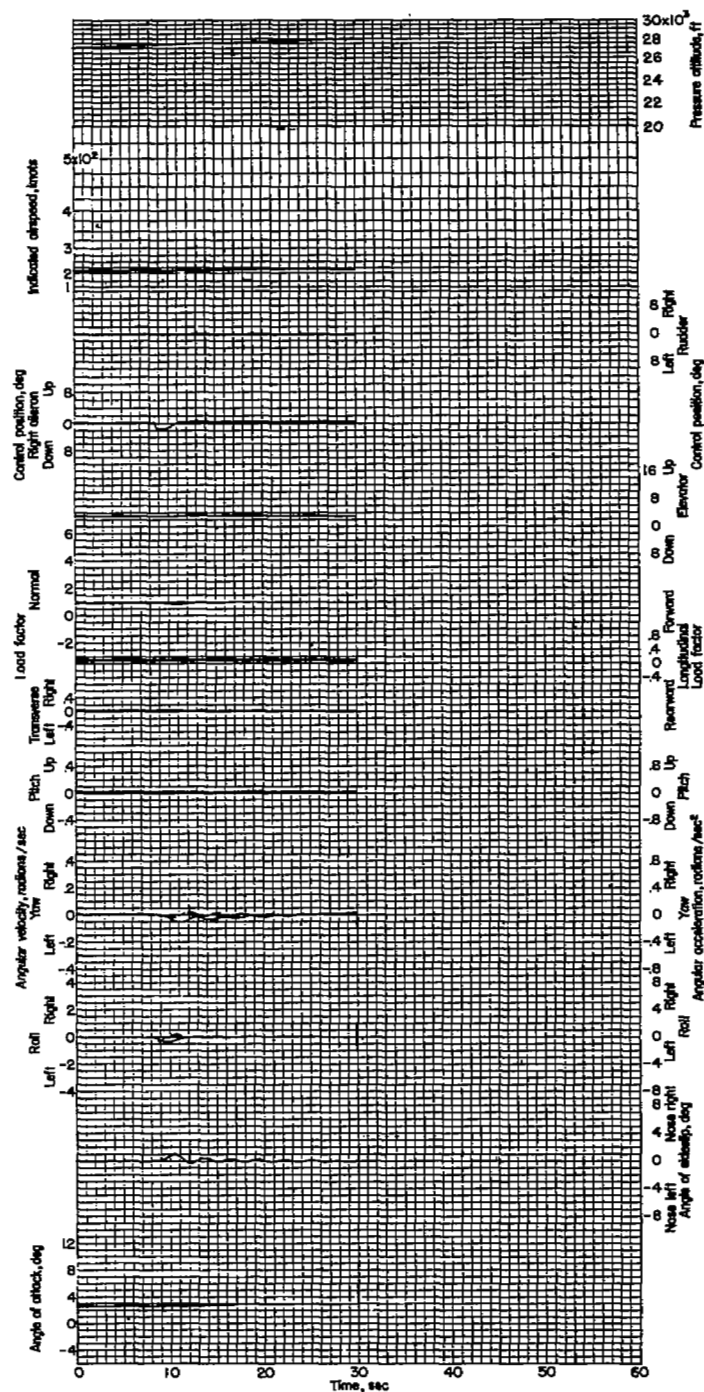


Figure 53.- Left climbing turn. Pilot B with radar observer; airplane weight, 12,360 pounds; center of gravity at 26.3 percent M.A.C.

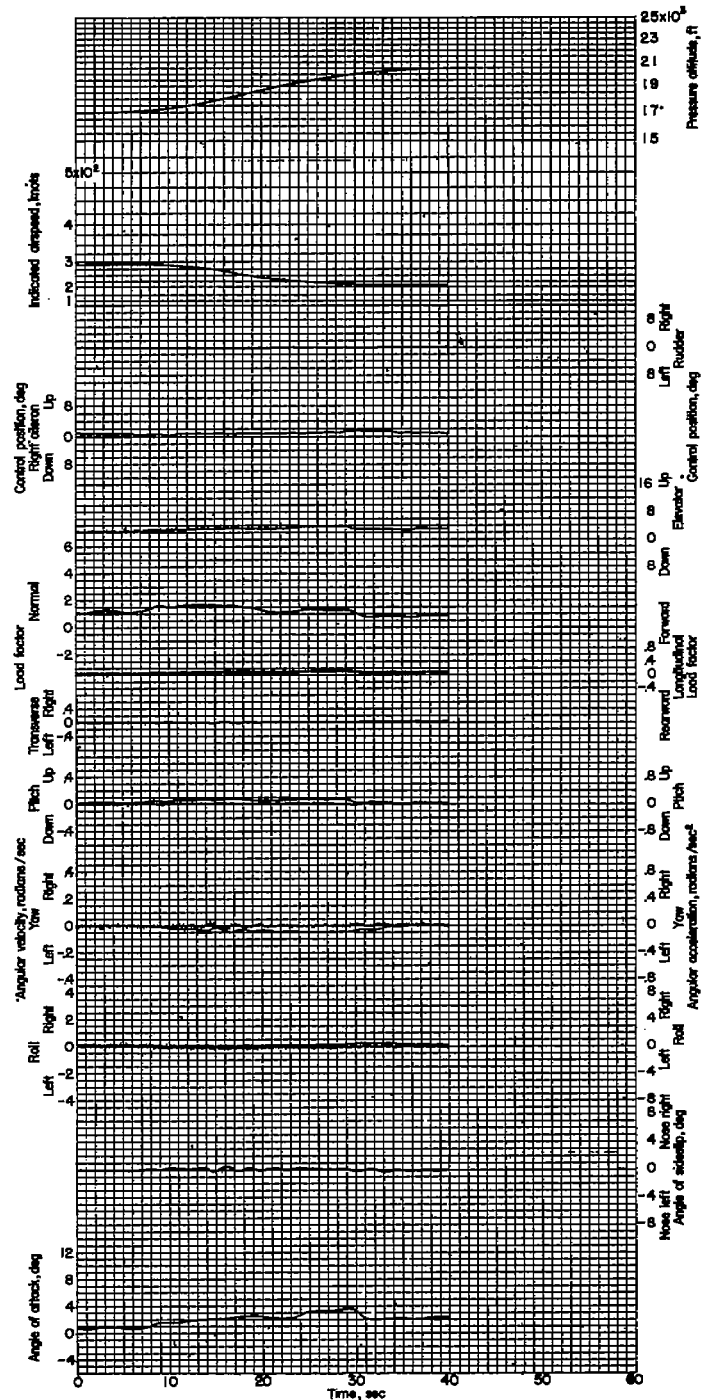


Figure 54.- Left climbing turn. Pilot E wearing anti-gravity suit; airplane weight, 12,290 pounds; center of gravity at 27.5 percent M.A.C.

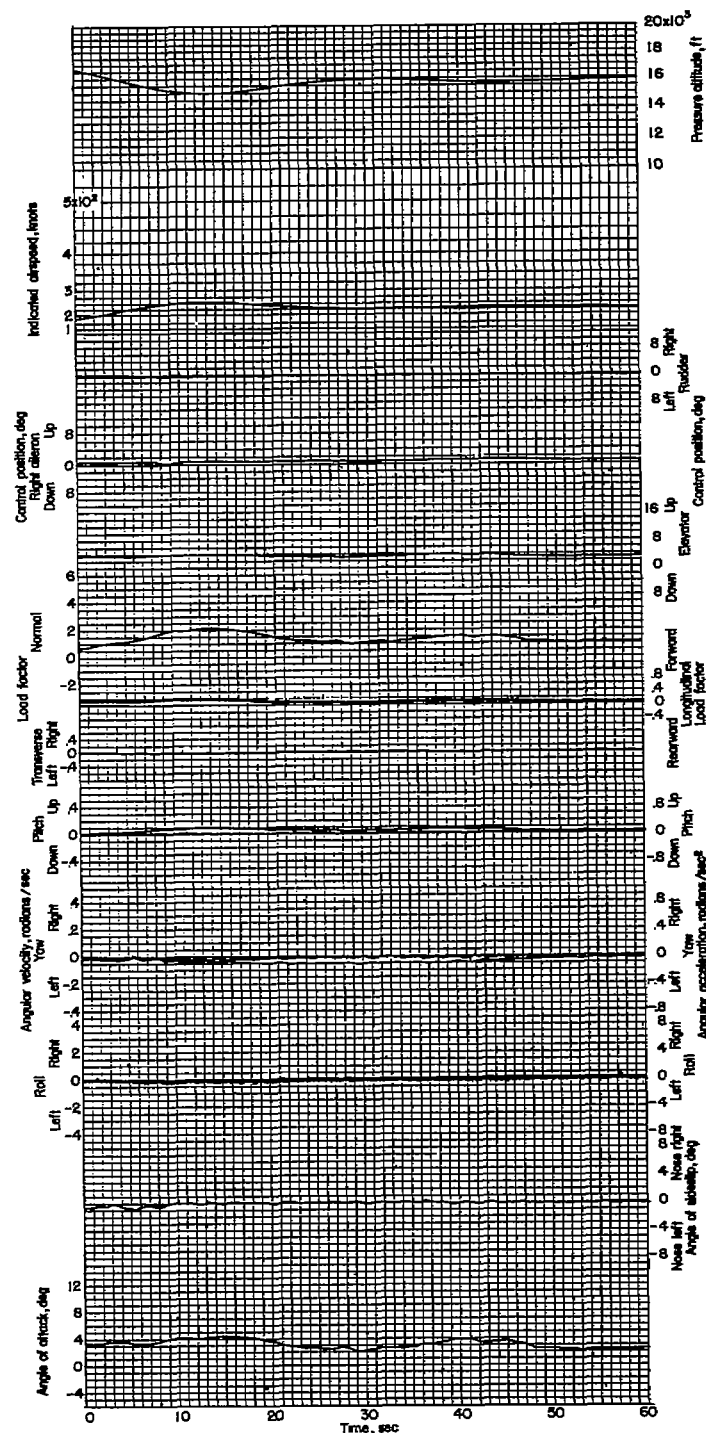


Figure 55.- Left climbing turn. Pilot F wearing anti-gravity suit; airplane weight, 12,560 pounds; center of gravity at 27.8 percent M.A.C.

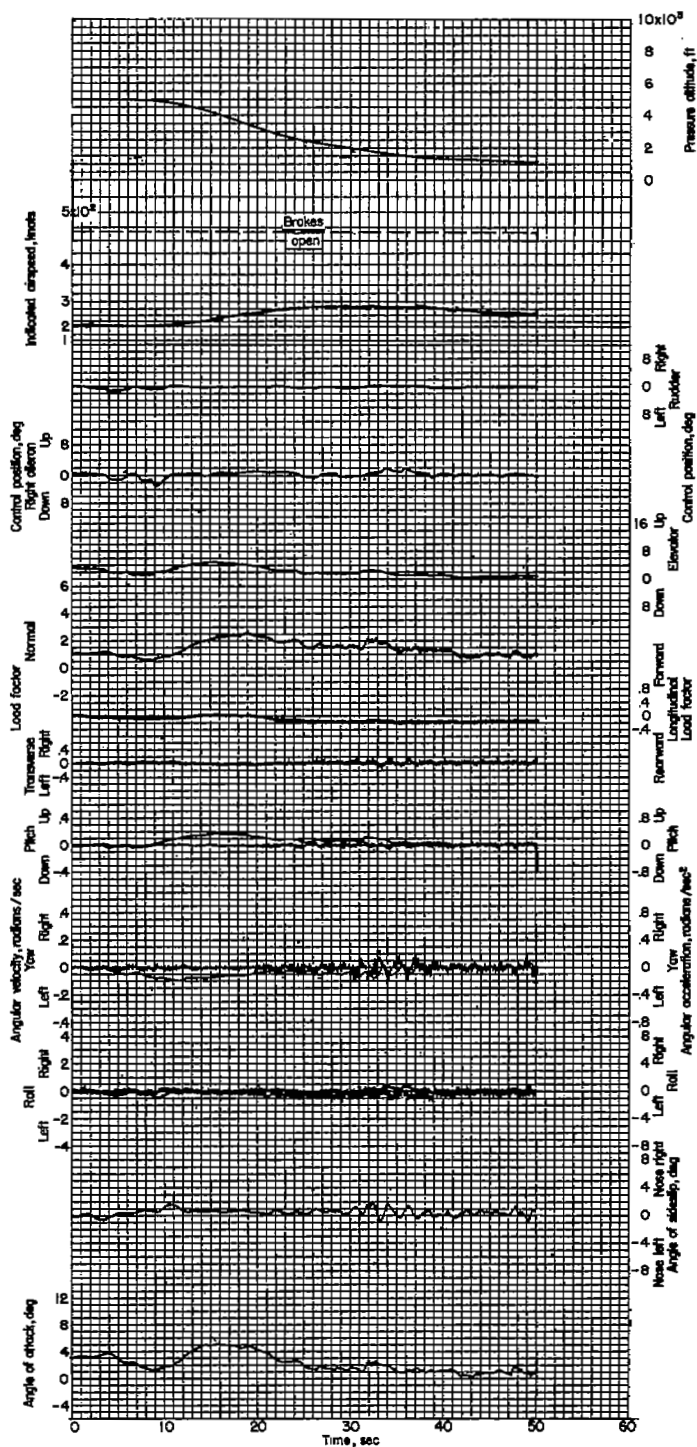


Figure 56.- Left diving turn. Pilot A; airplane weight, 11,450 pounds; center of gravity at 25.8 percent M.A.C.

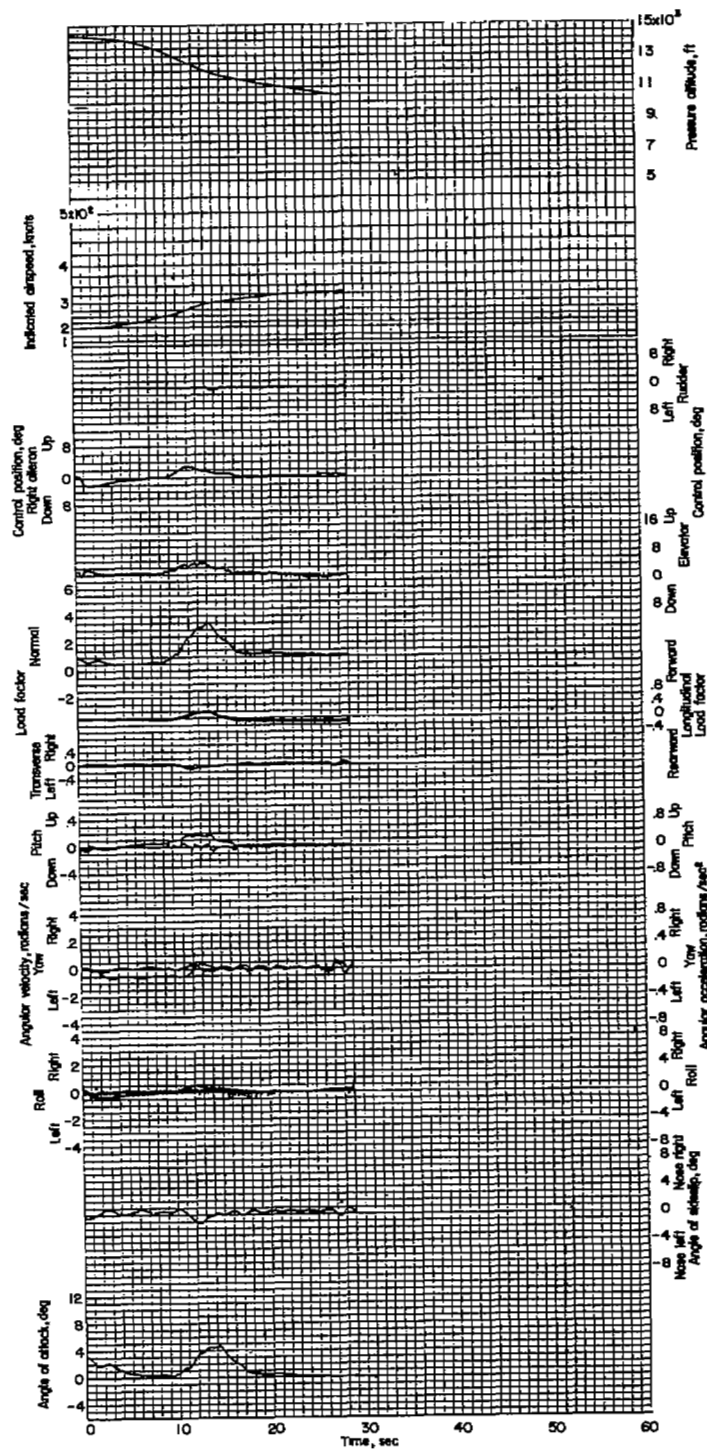
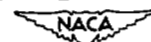


Figure 57.- Left diving turn. Pilot B; airplane weight, 11,700 pounds; center of gravity at 26.3 percent M.A.C.



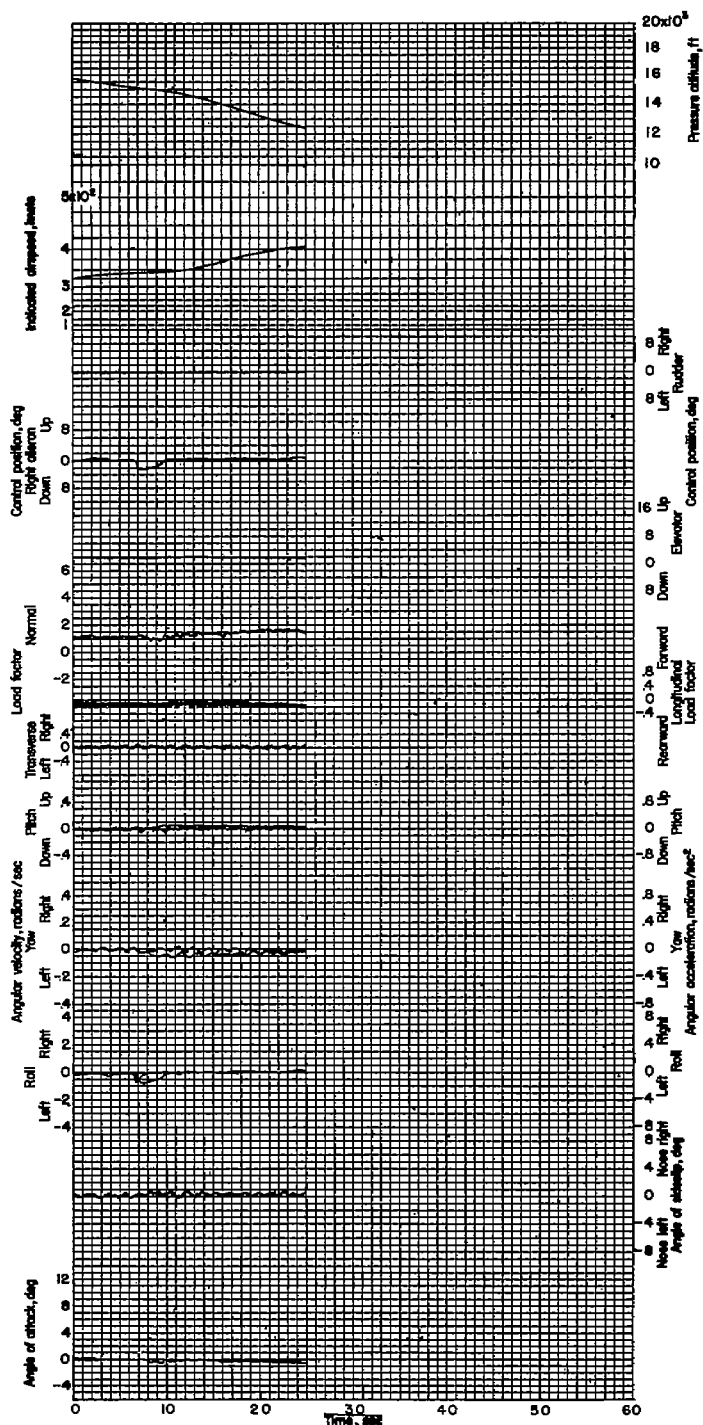


Figure 58.- Left diving turn. Pilot B with radar observer; airplane weight, 12,060 pounds; center of gravity at 25.7 percent M.A.C.

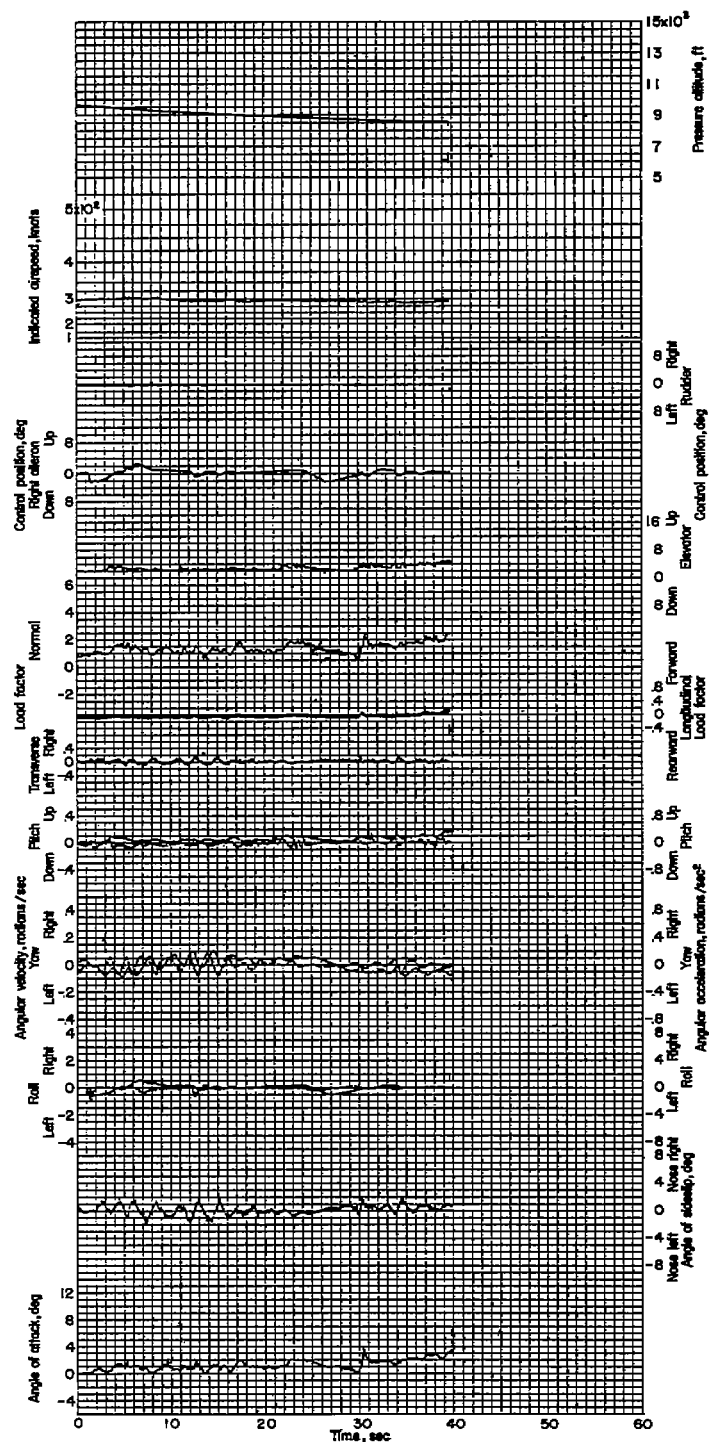
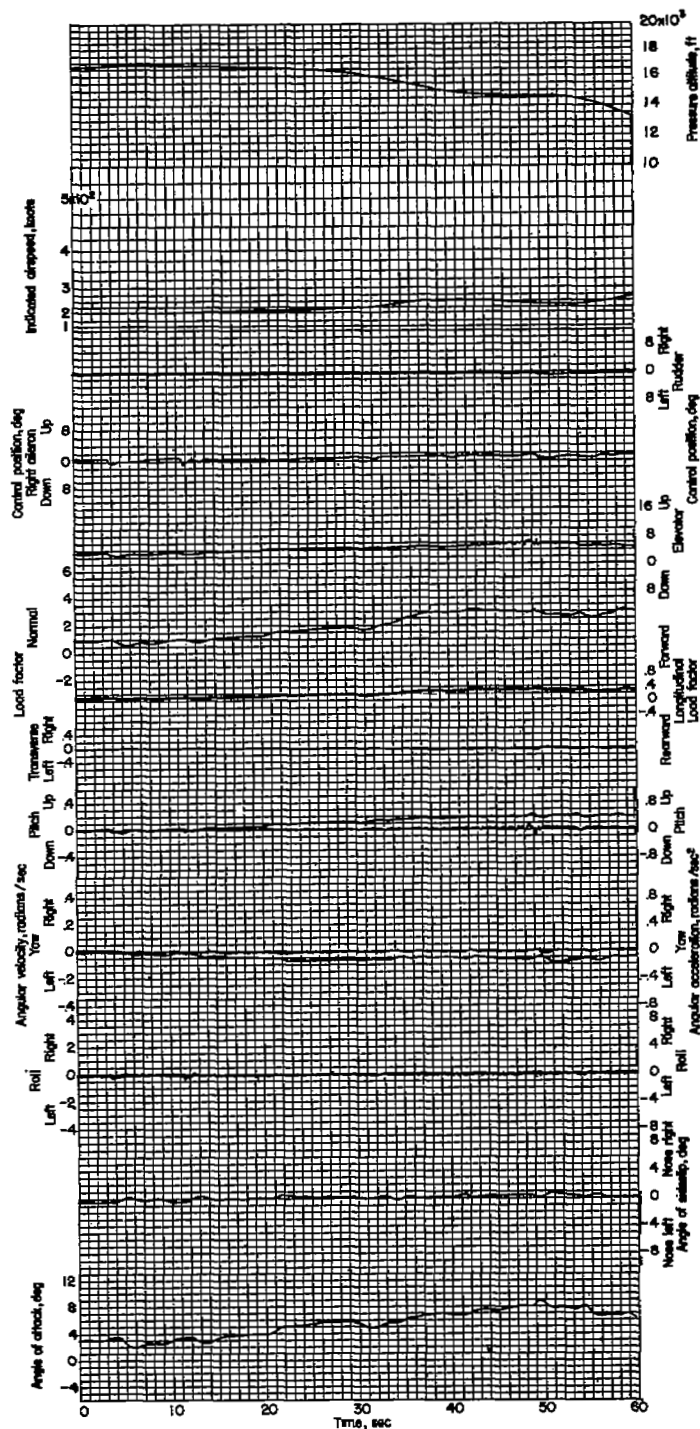


Figure 59.- Left diving turns. Pilot B with radar observer; airplane weight, 12,000 pounds; center of gravity at 25.5 percent M.A.C.



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Figure 60.- Left diving turns. Pilot F wearing anti-gravity suit; airplane weight, 12,480 pounds; center of gravity at 27.8 percent M.A.C.

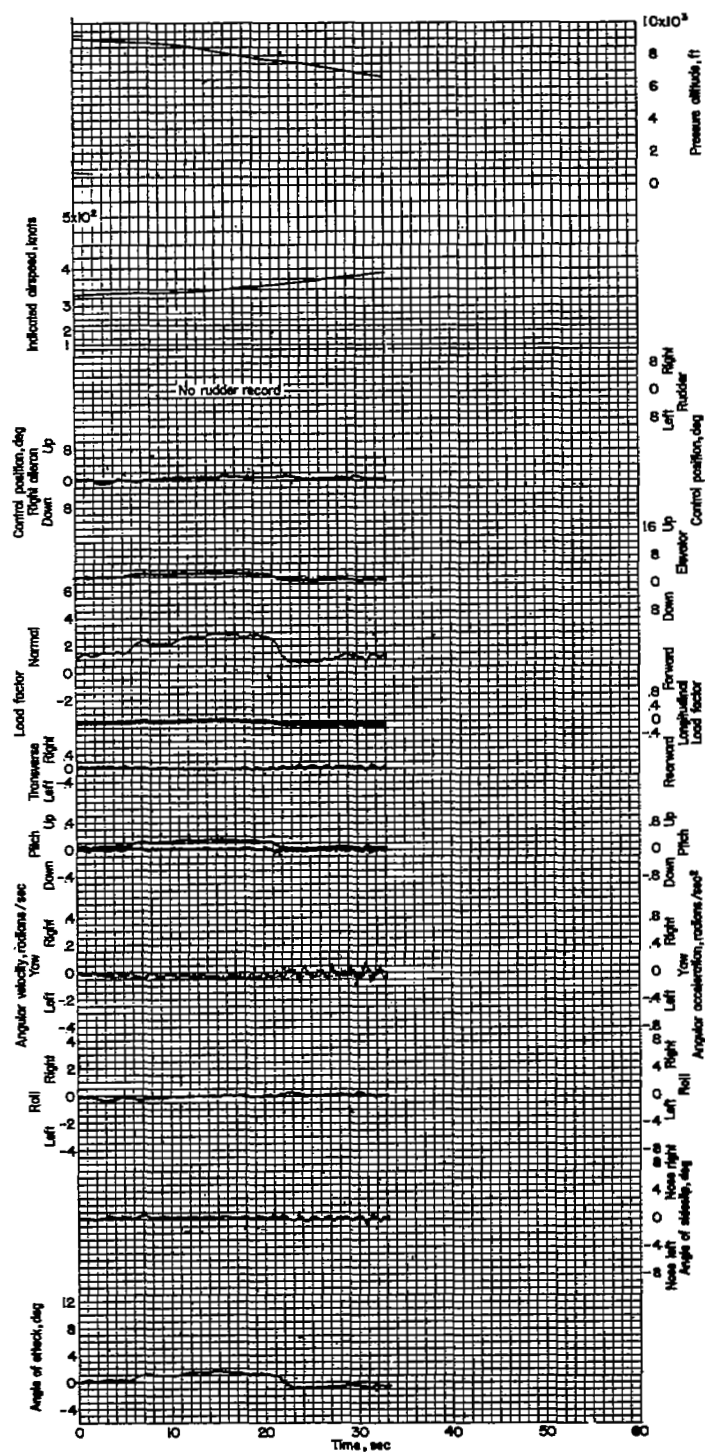
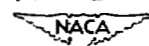


Figure 61.- Left diving turn. Pilot G; airplane weight, 11,780 pounds; center of gravity at 26.4 percent M.A.C.



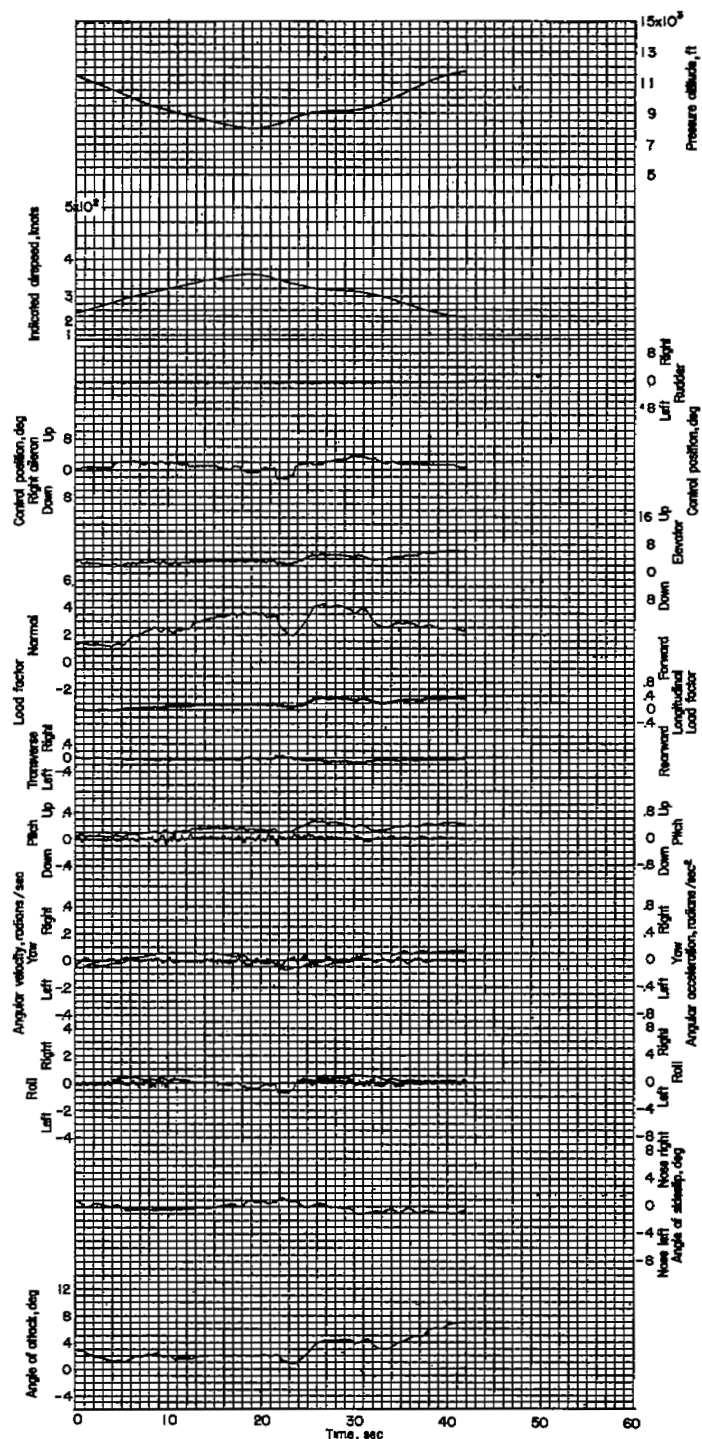
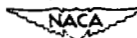


Figure 62.- Diving and climbing turns. Pilot B; airplane weight, 11,860 pounds; center of gravity at 26.6 percent M.A.C.



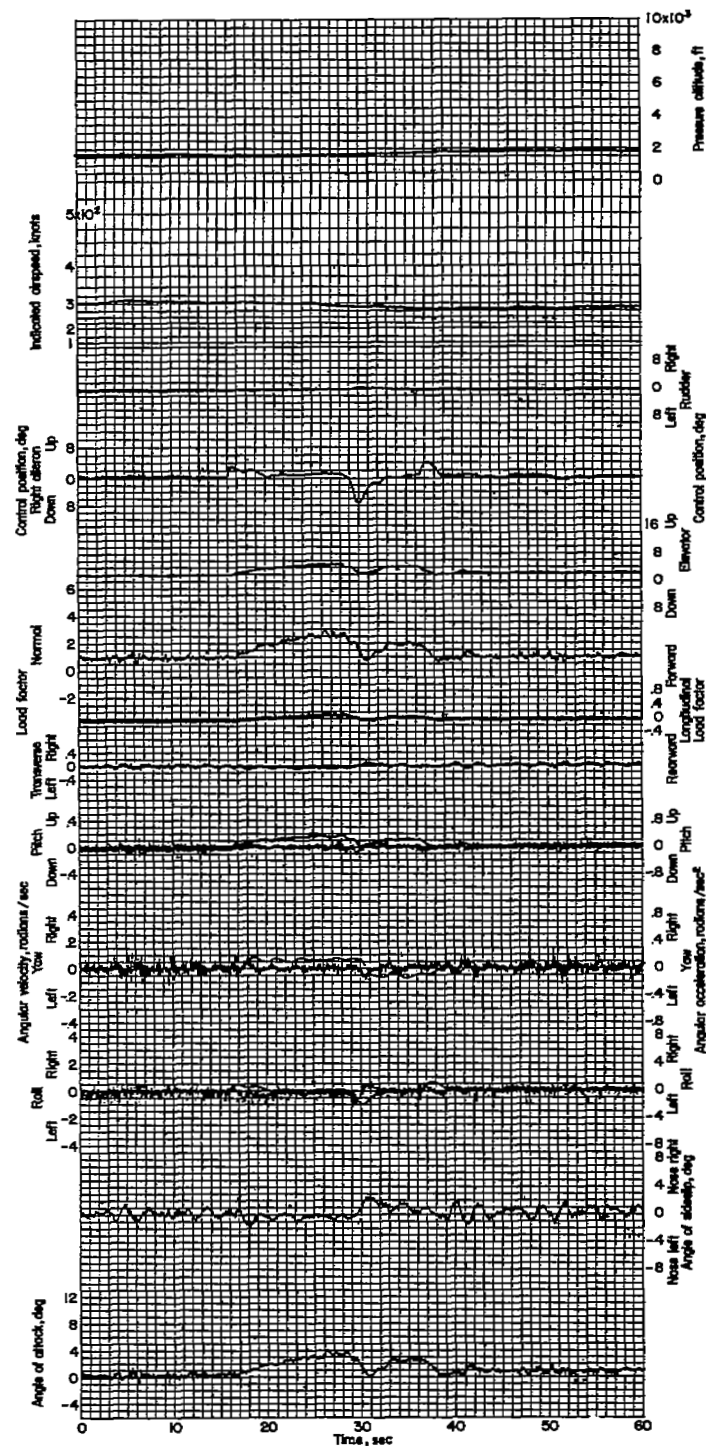


Figure 63.- Right and left turns. Pilot E wearing anti-gravity suit and with radar observer; tip tanks on; airplane weight, 14,820 pounds; center of gravity at 27.7 percent M.A.C.

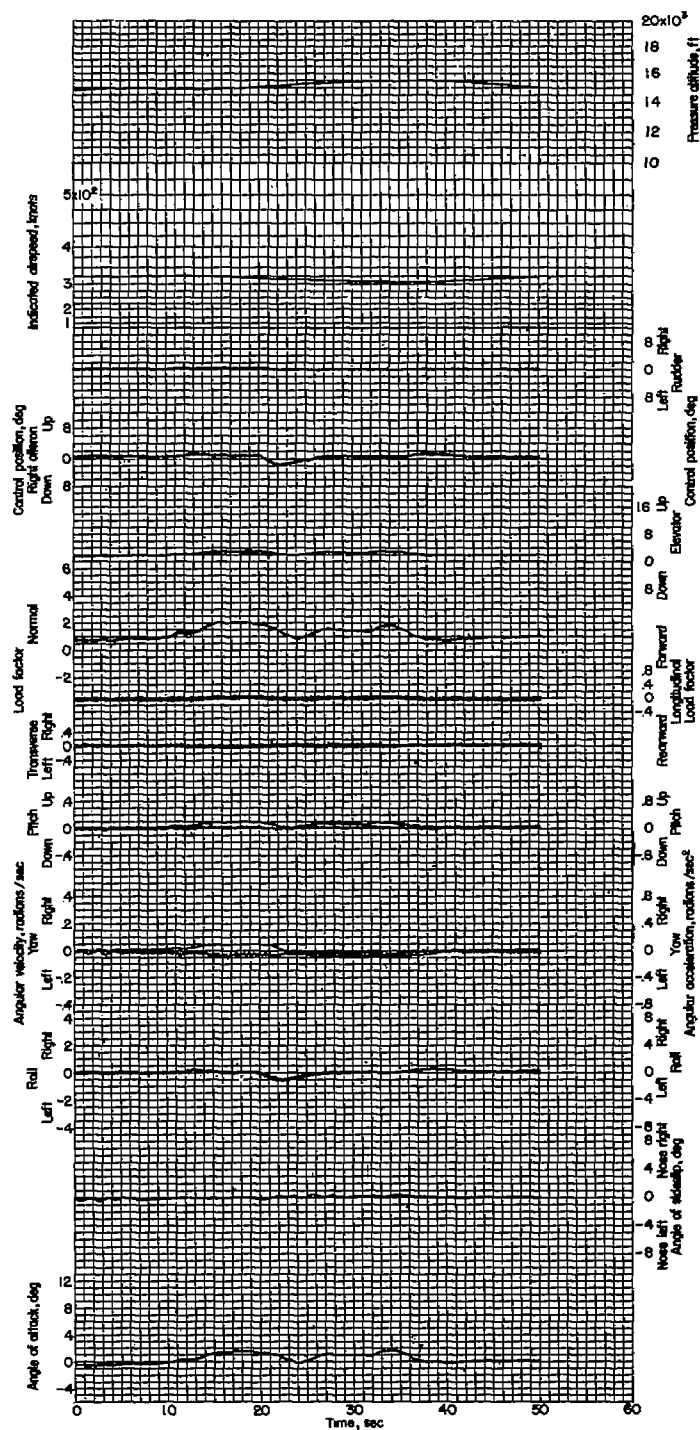


Figure 64.- Right and left turns. Pilot F wearing anti-gravity suit and with radar observer; airplane weight, 12,410 pounds; center of gravity at 26.4 percent M.A.C.

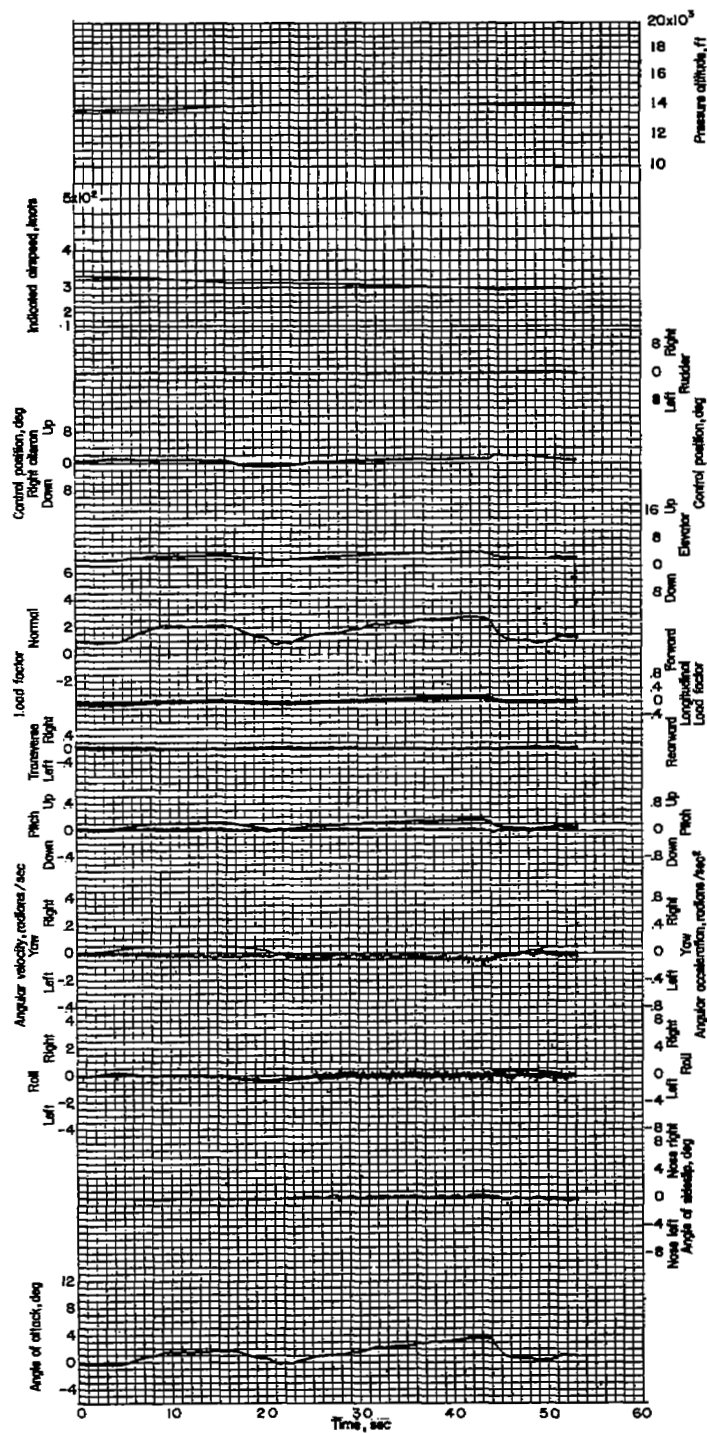
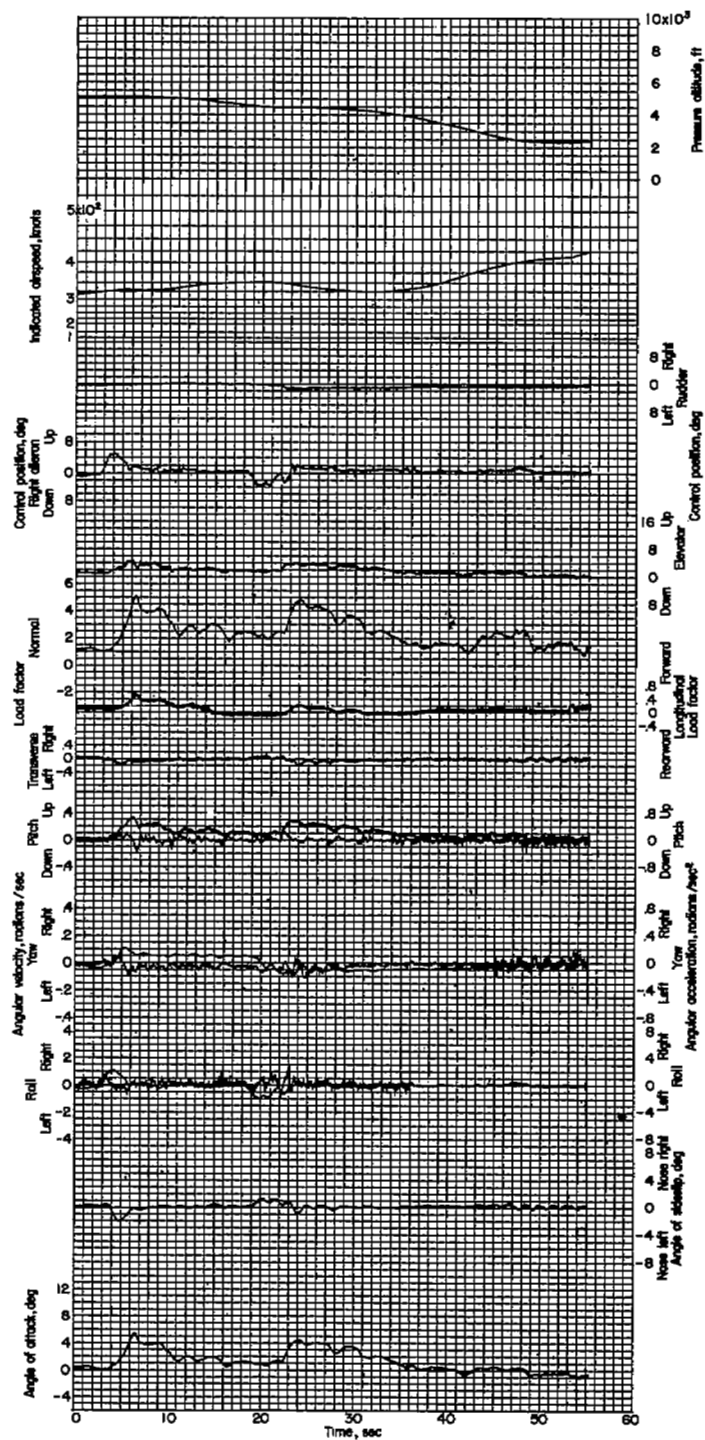


Figure 65.- Right and left turns. Pilot F wearing anti-gravity suit and with radar observer; airplane weight, 12,300 pounds; center of gravity at 26.2 percent M.A.C.



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Figure 66.- Right and left diving turns. Pilot G; airplane weight, 12,680 pounds; airplane center of gravity at 27.7 percent M.A.C.

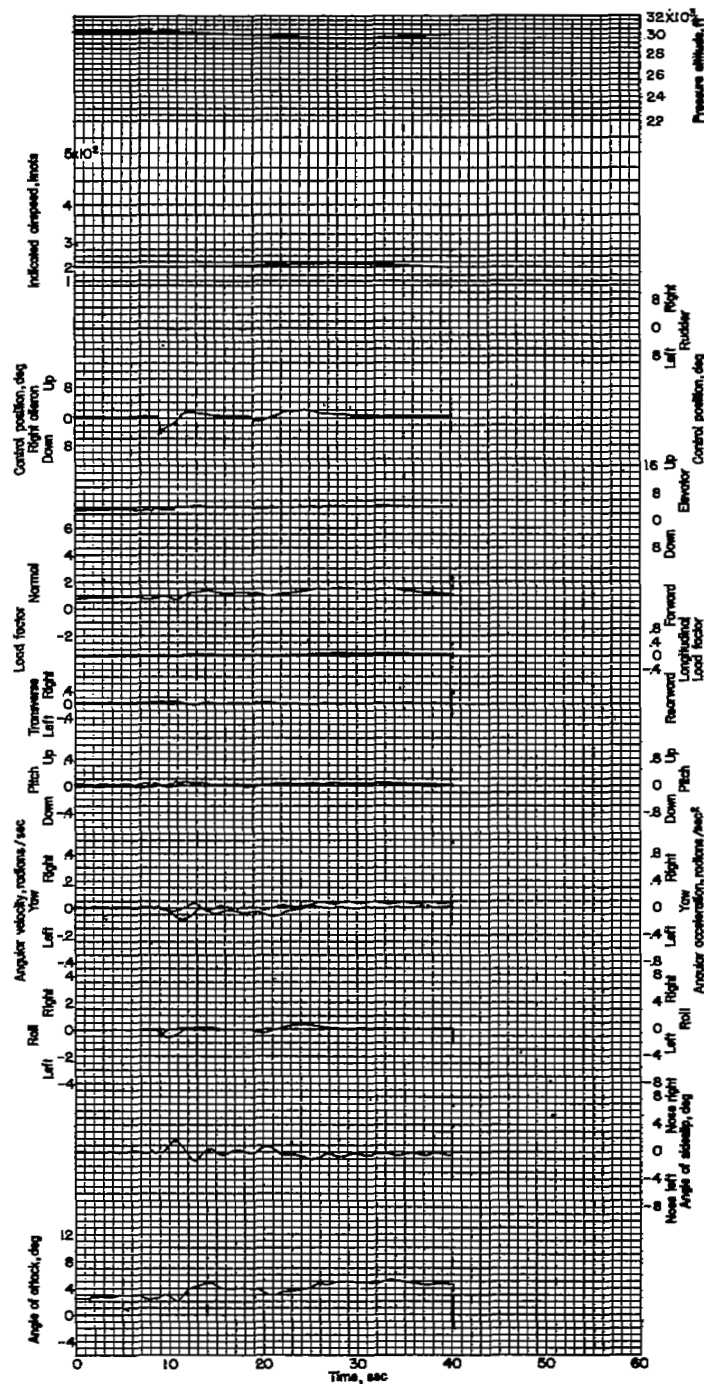


Figure 67.- Left and right turns. Pilot B with radar observer; airplane weight, 12,250 pounds; center of gravity at 26.0 percent M.A.C.

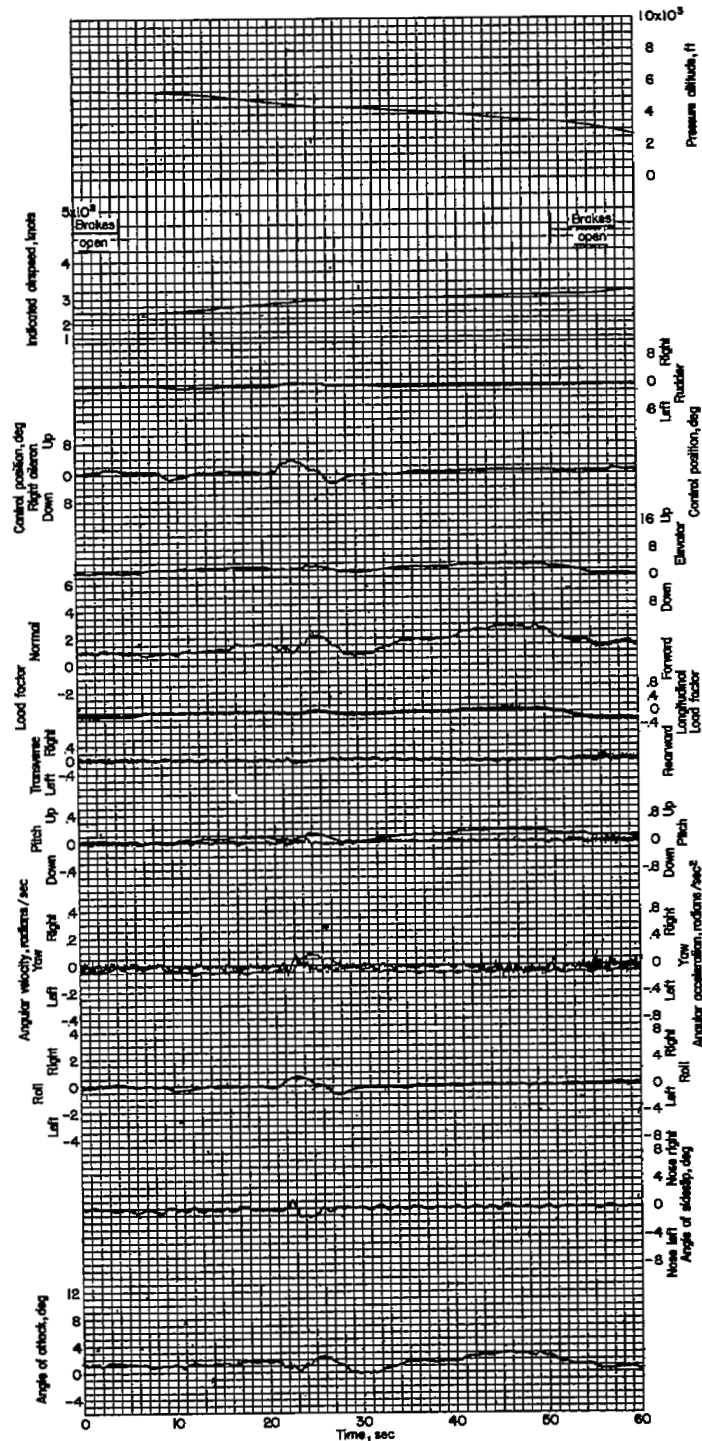


Figure 68.- Left and right turn. Pilot F wearing anti-gravity suit and with radar observer; airplane weight, 11,960 pounds; center of gravity at 25.5 percent M.A.C.

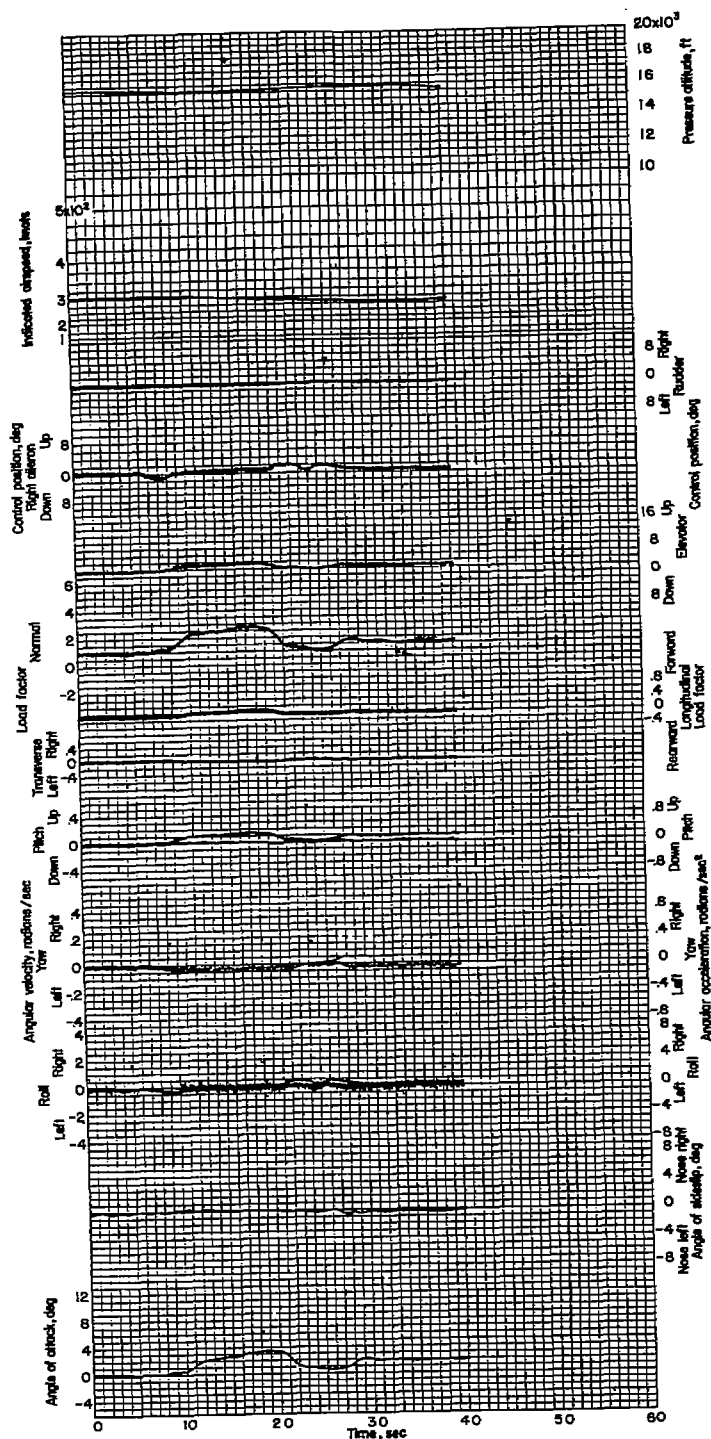


Figure 69.- Left and right turns. Pilot F wearing anti-gravity suit and with radar observer; airplane weight, 12,380 pounds; center of gravity at 26.3 percent M.A.C.

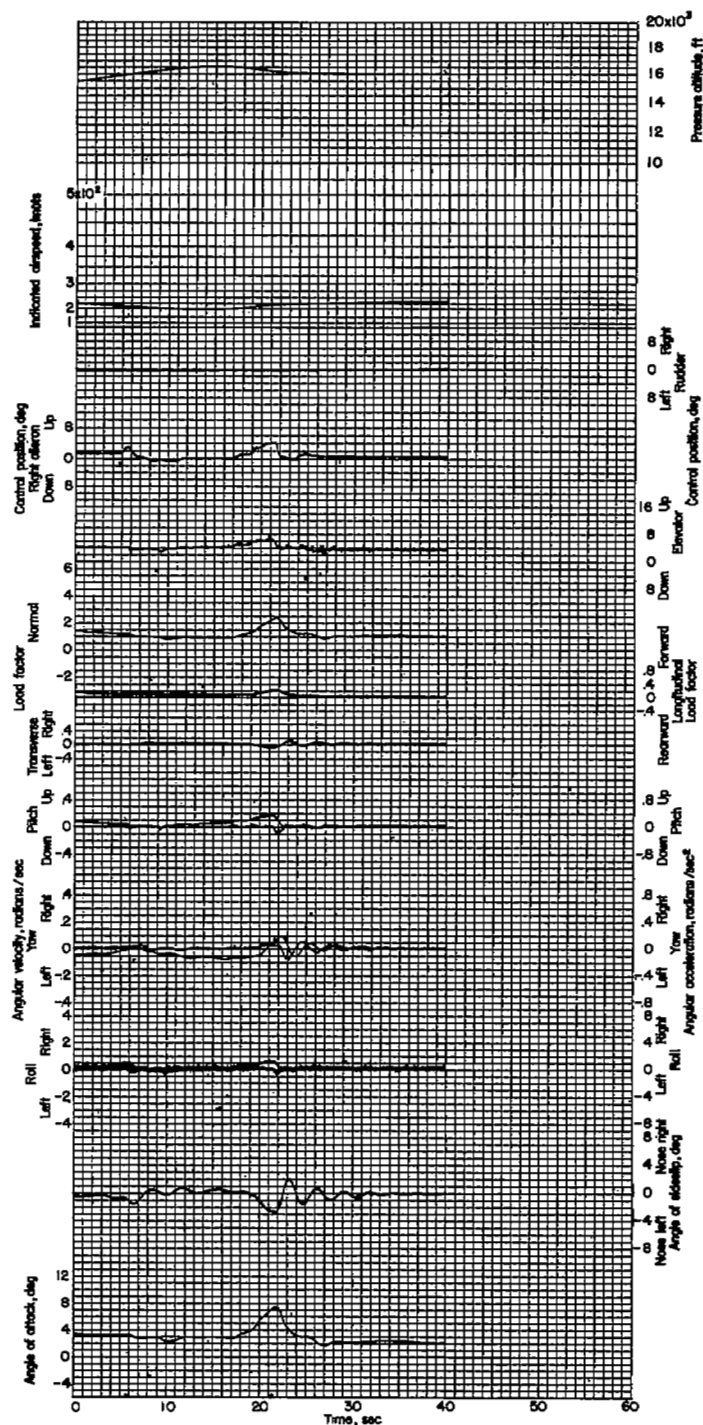
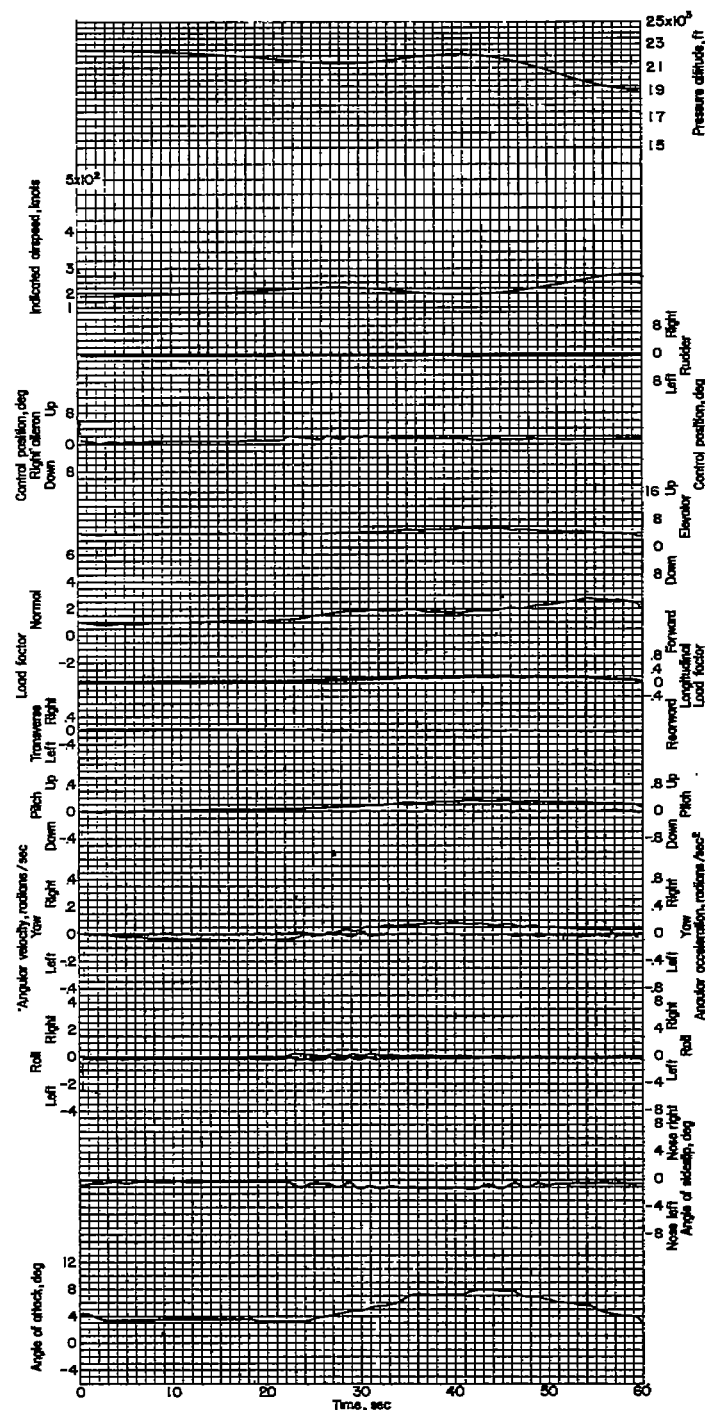


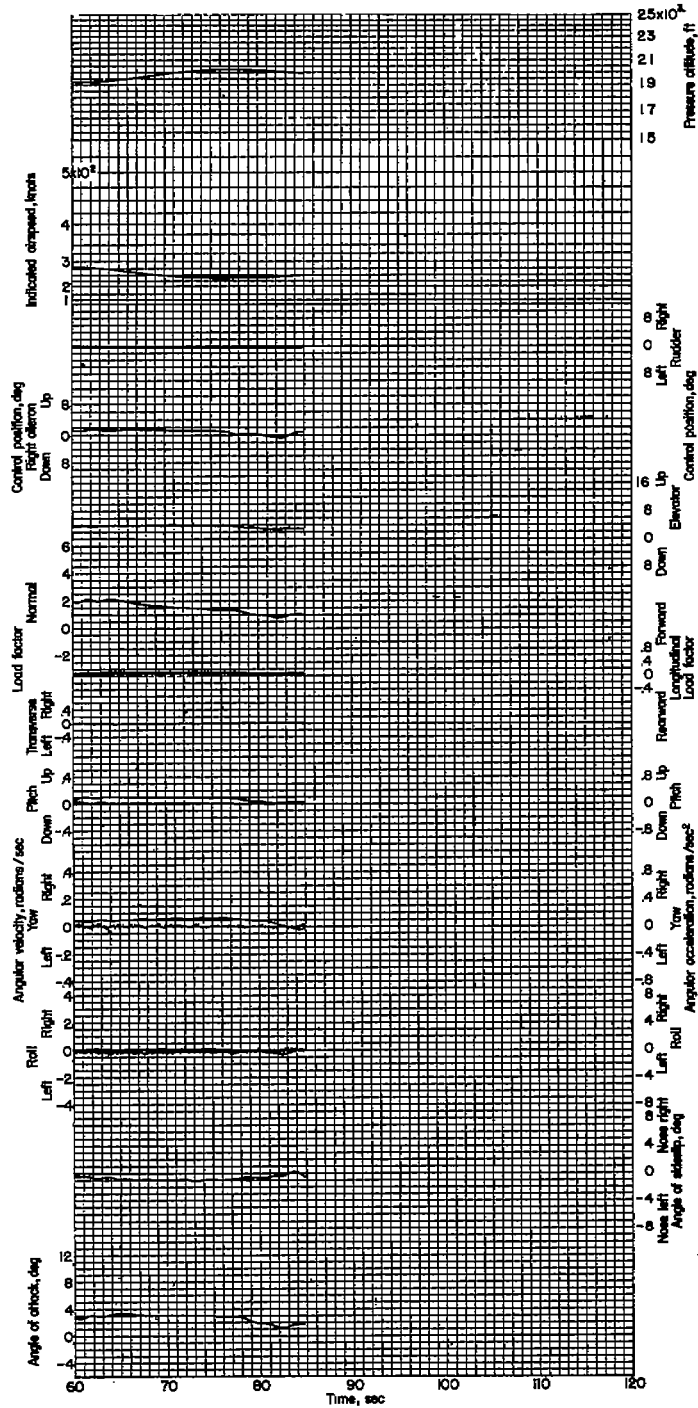
Figure 70.- Left climbing turn followed by right turn. Pilot B; airplane weight, 11,860 pounds; center of gravity at 26.6 percent M.A.C.



(a)



Figure 71.- Left turn followed by right diving turn. Pilot E wearing anti-gravity suit; airplane weight, 11,940 pounds; center of gravity at 26.8 percent M.A.C.



(b)

Figure 71.- Concluded.



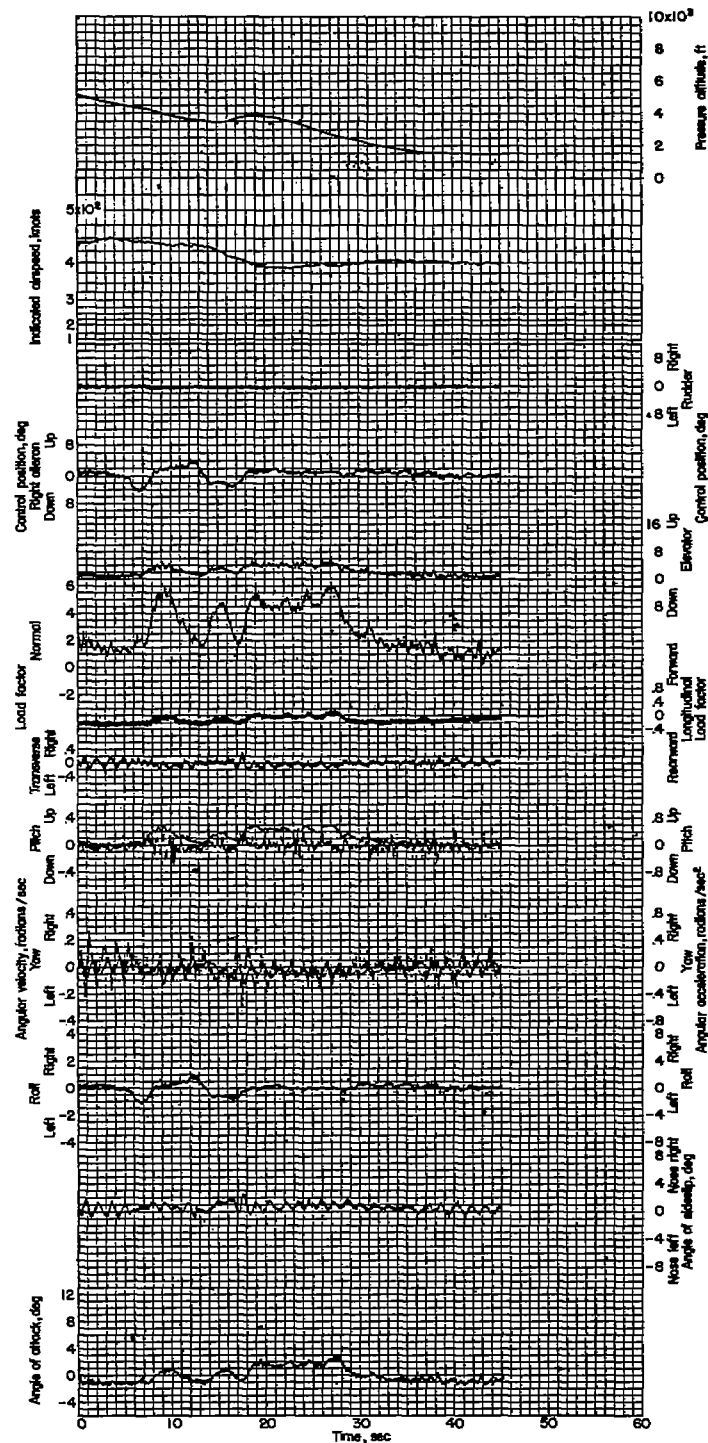


Figure 72.- Left, right, and left diving turns. Pilot B; airplane weight, 11,640 pounds; center of gravity at 26.2 percent M.A.C.

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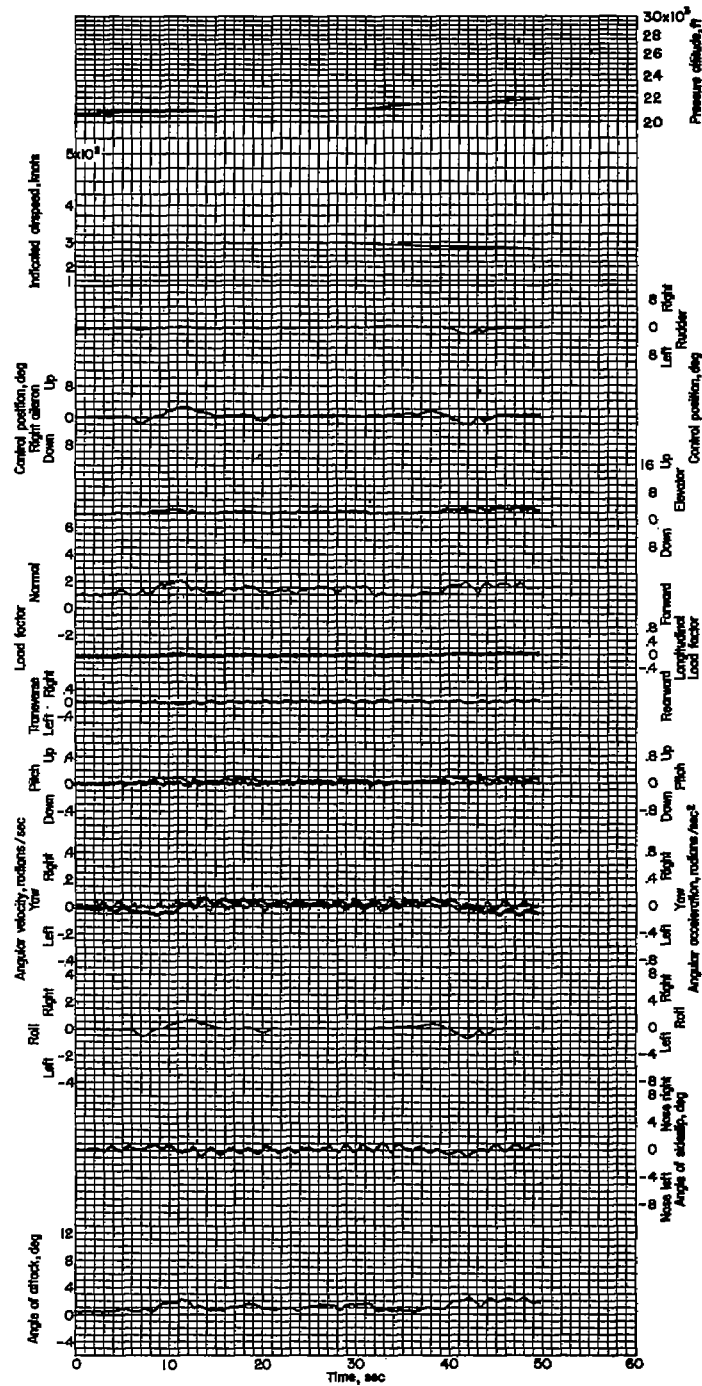


Figure 73.- Series of turns. Pilot C with radar observer; airplane weight, 12,500 pounds; center of gravity at 26.6 percent M.A.C.

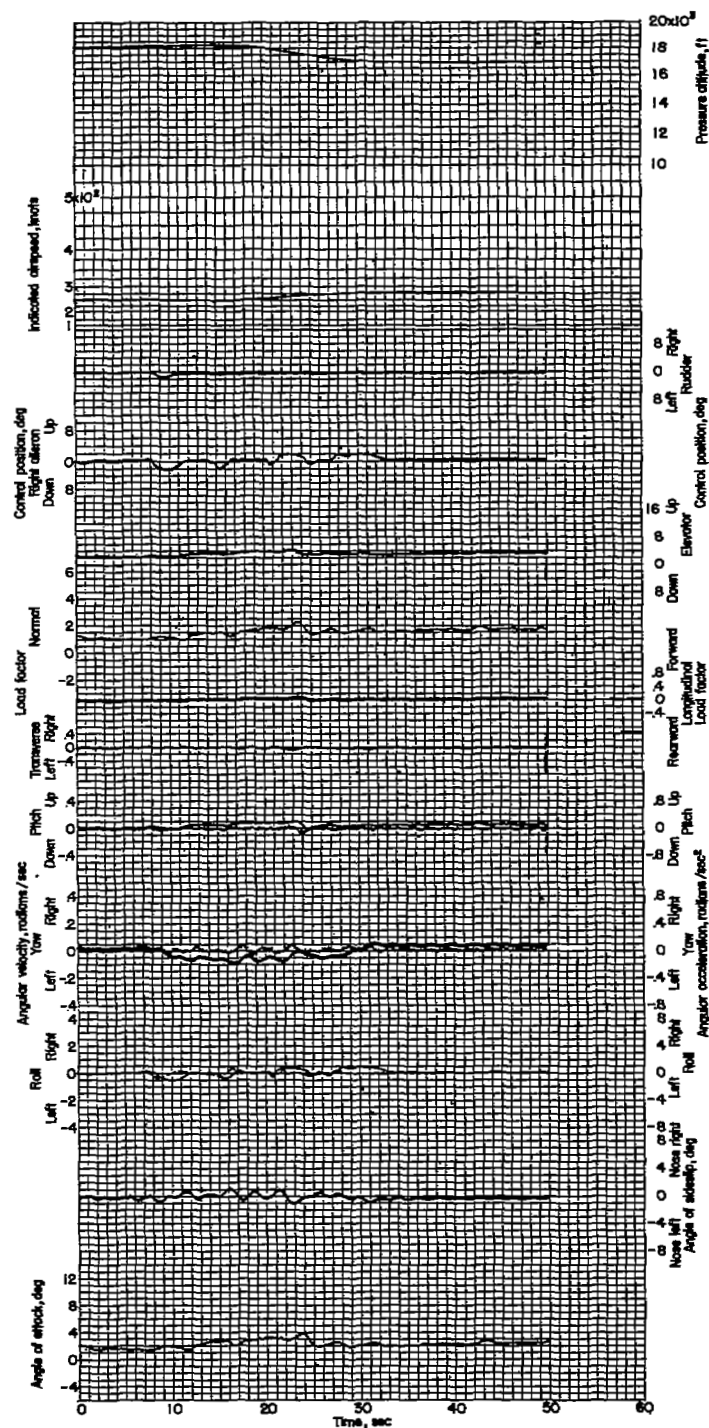


Figure 74.- Series of turns. Pilot C with radar observer; airplane weight, 12,100 pounds; center of gravity at 25.8 percent M.A.C.

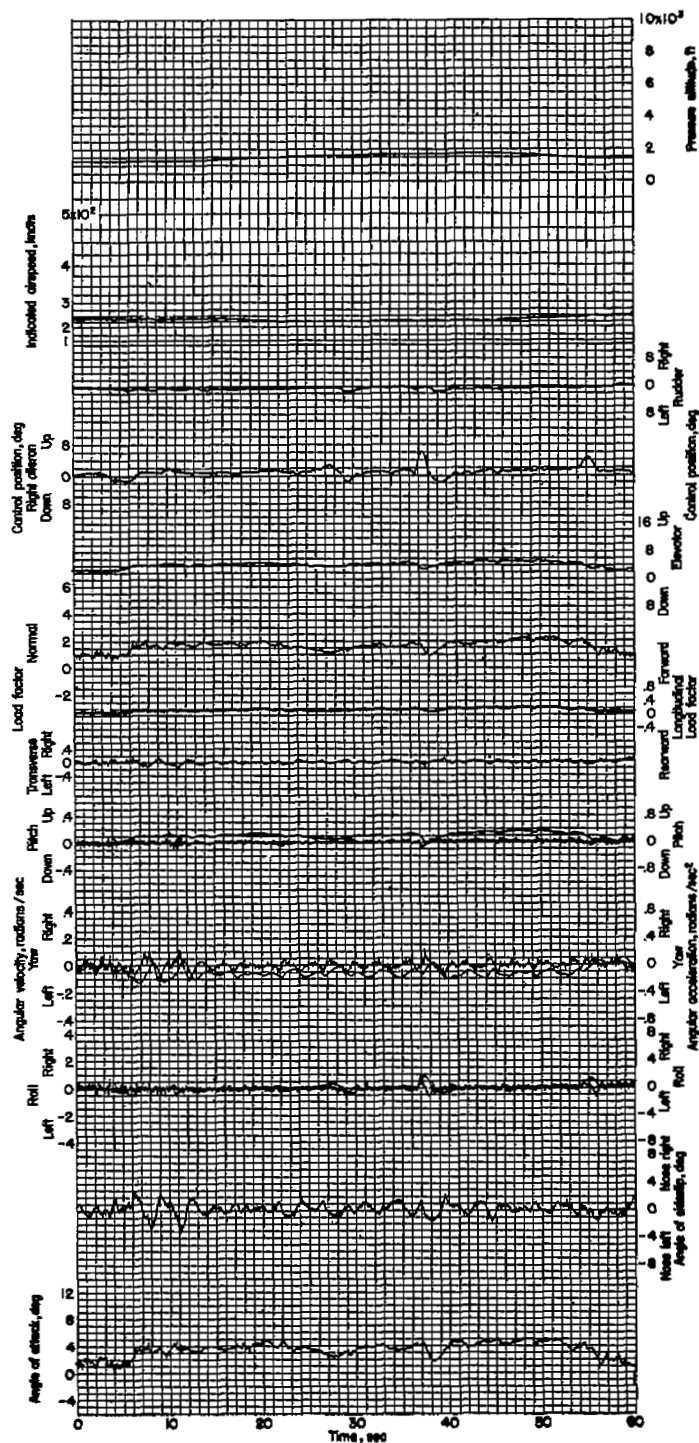


Figure 75.- Series of turns. Pilot E wearing anti-gravity suit; airplane weight, 11,510 pounds; center of gravity at 25.9 percent M.A.C.

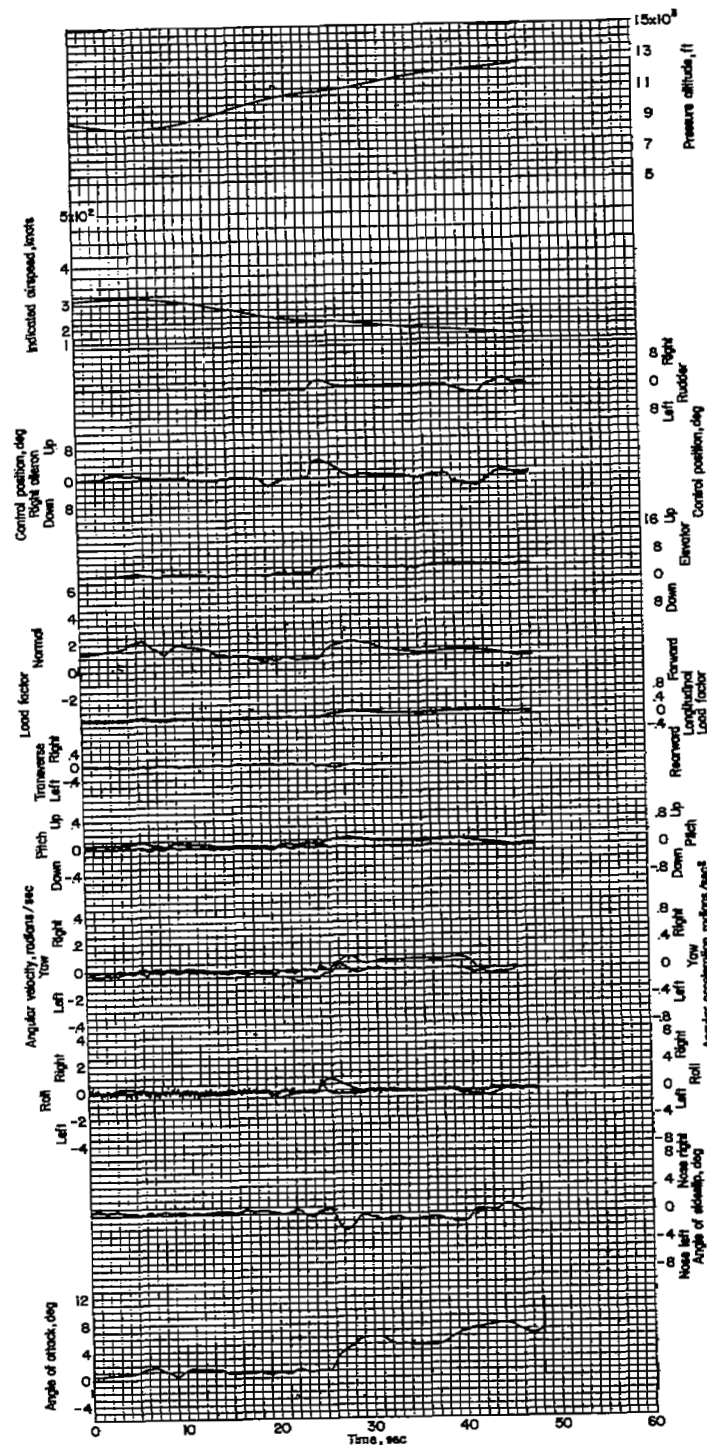


Figure 76.-Series of climbing turns. Pilot A wearing anti-gravity suit; airplane weight, 12,020 pounds; center of gravity at 26.9 percent M.A.C.

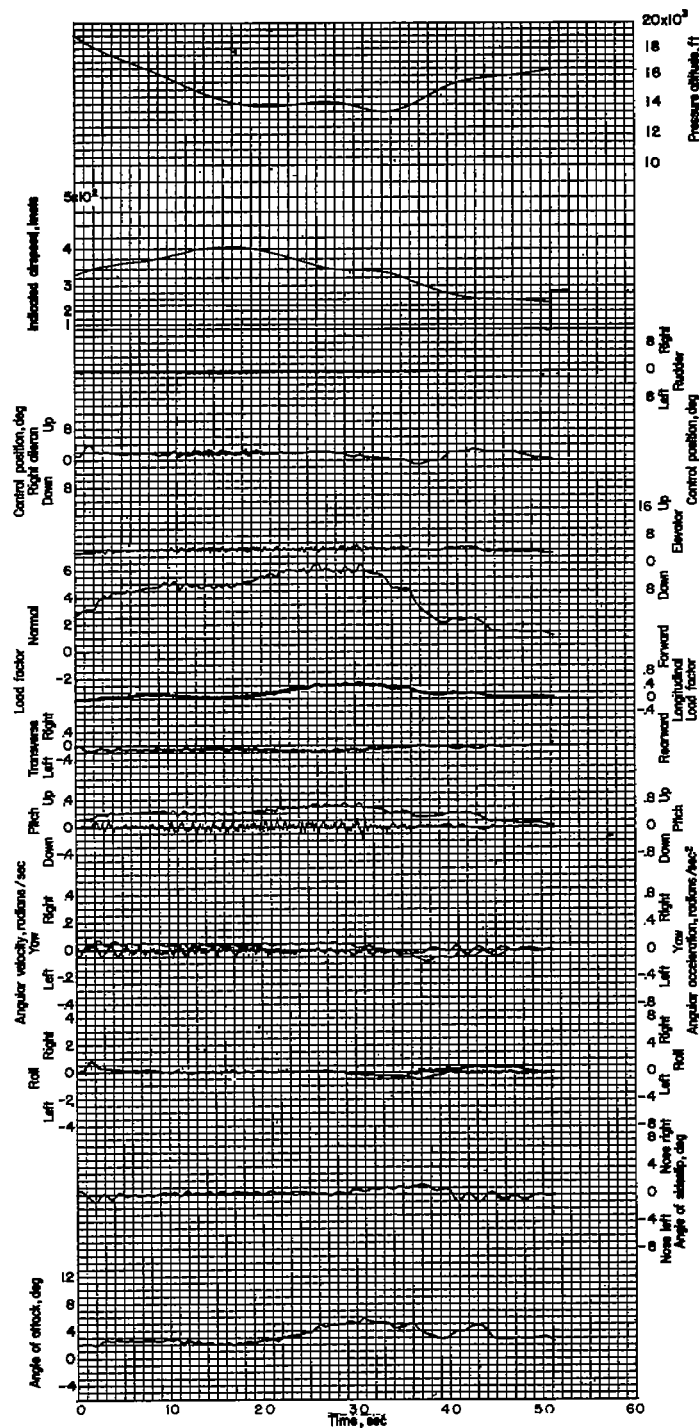


Figure 77.- Series of diving and climbing turns. Pilot B; airplane weight, 12,140 pounds; center of gravity at 27.2 percent M.A.C.

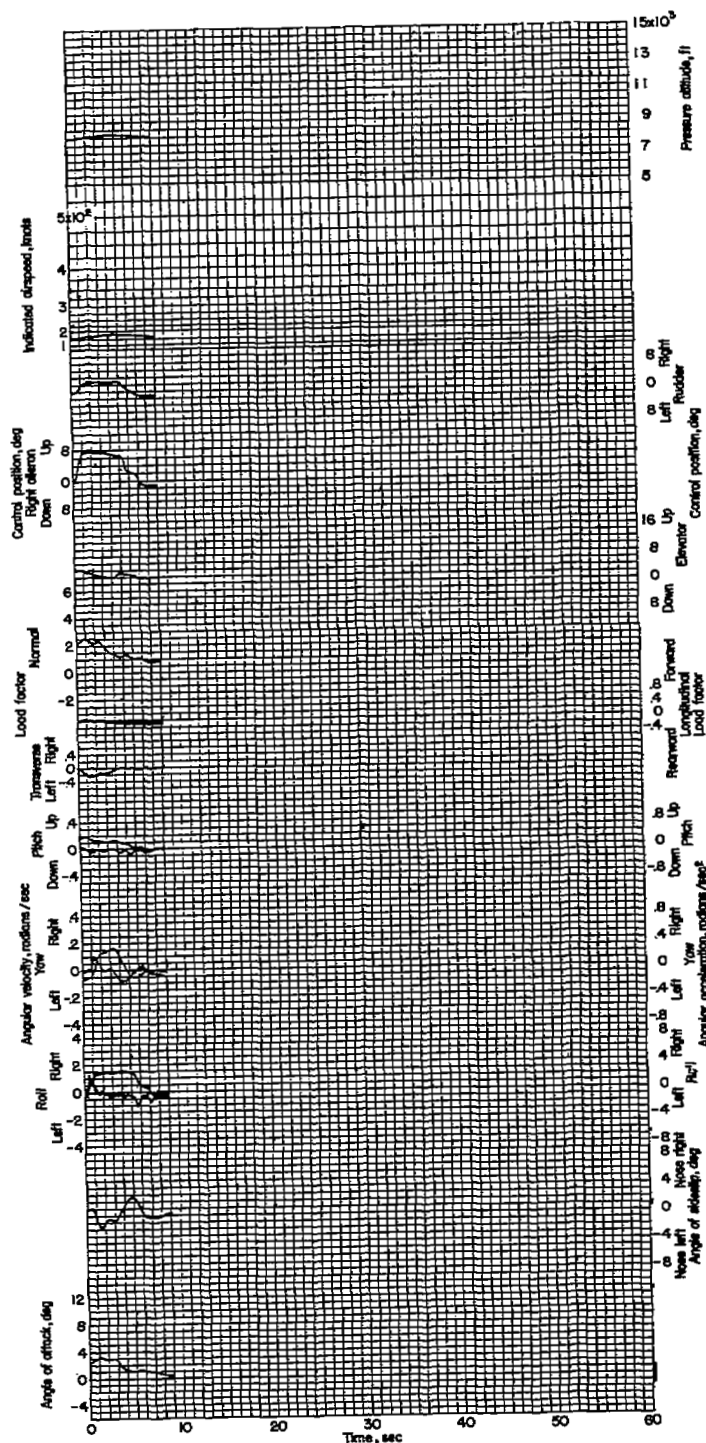


Figure 78.- Right aileron roll. Pilot A; airplane weight, 11,570 pounds; center of gravity at 26.0 percent M.A.C.



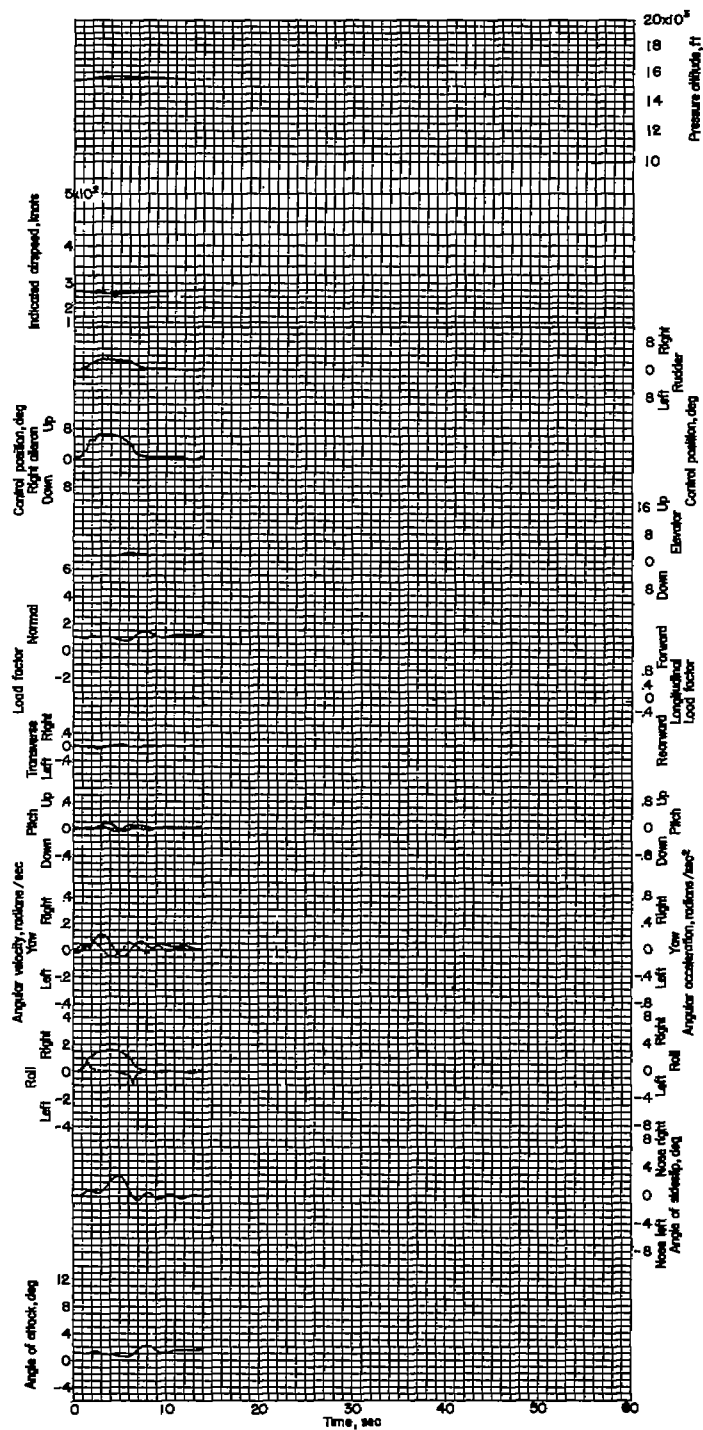
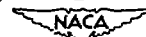


Figure 79.- Right aileron roll. Pilot A; airplane weight, 12,250 pounds; center of gravity at 27.4 percent M.A.C.



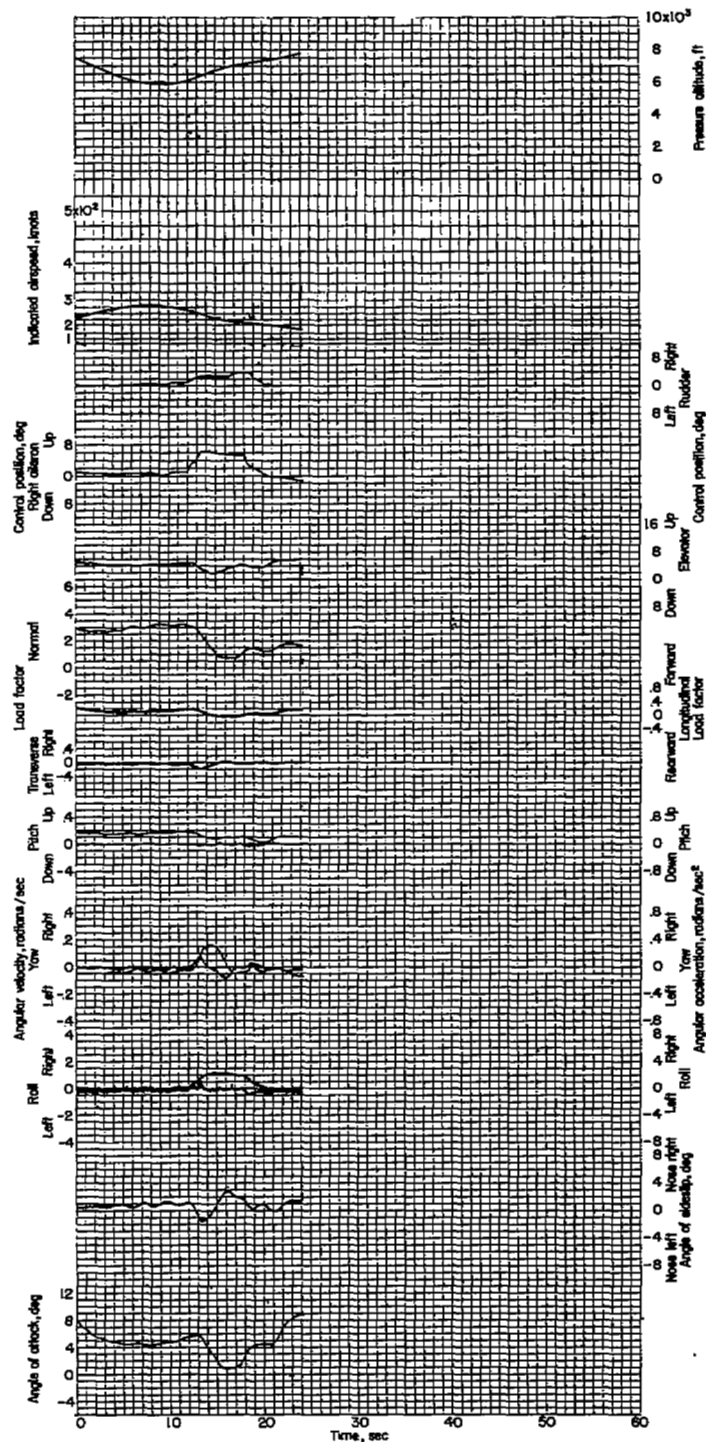


Figure 80.- Right aileron roll. Pilot A; airplane weight, 11,525 pounds; center of gravity at 25.9 percent M.A.C.

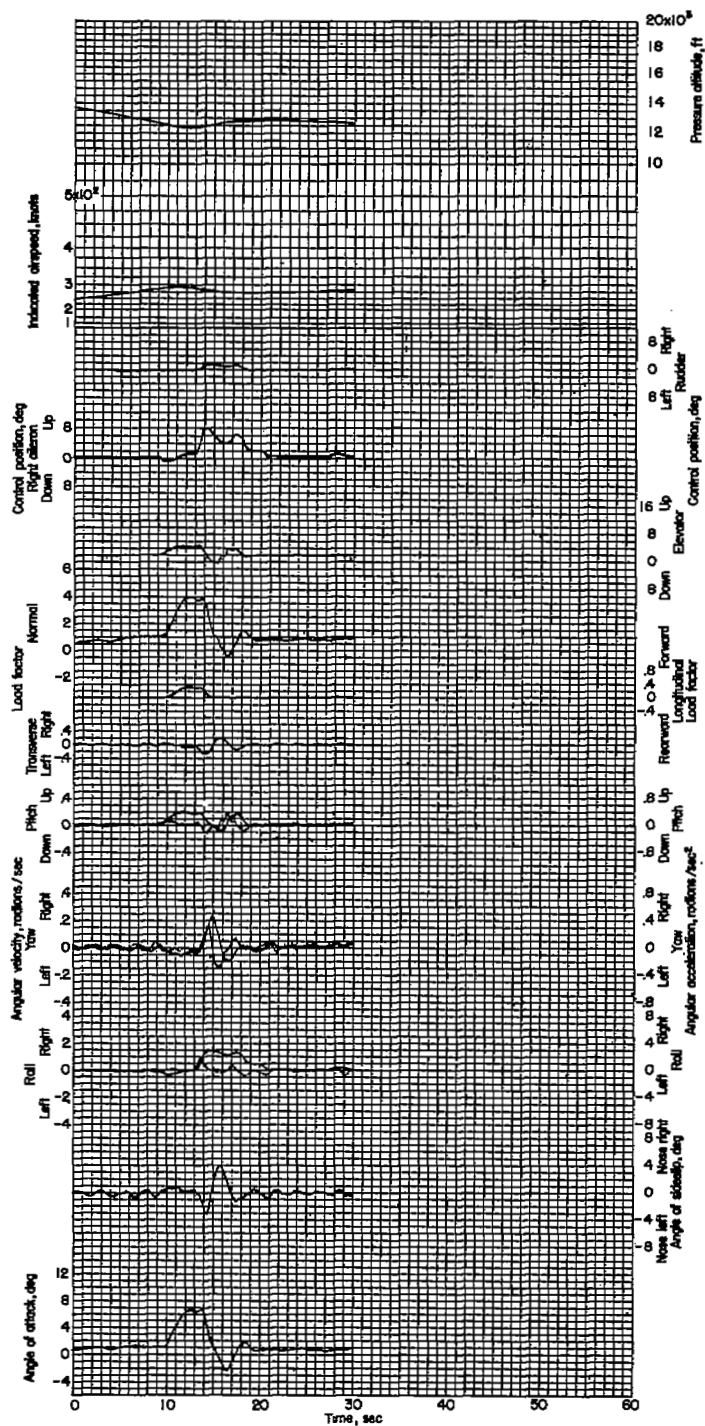
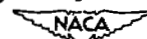


Figure 81.- Right aileron roll. Pilot A; airplane weight, 12,110 pounds; center of gravity at 27.1 percent M.A.C.



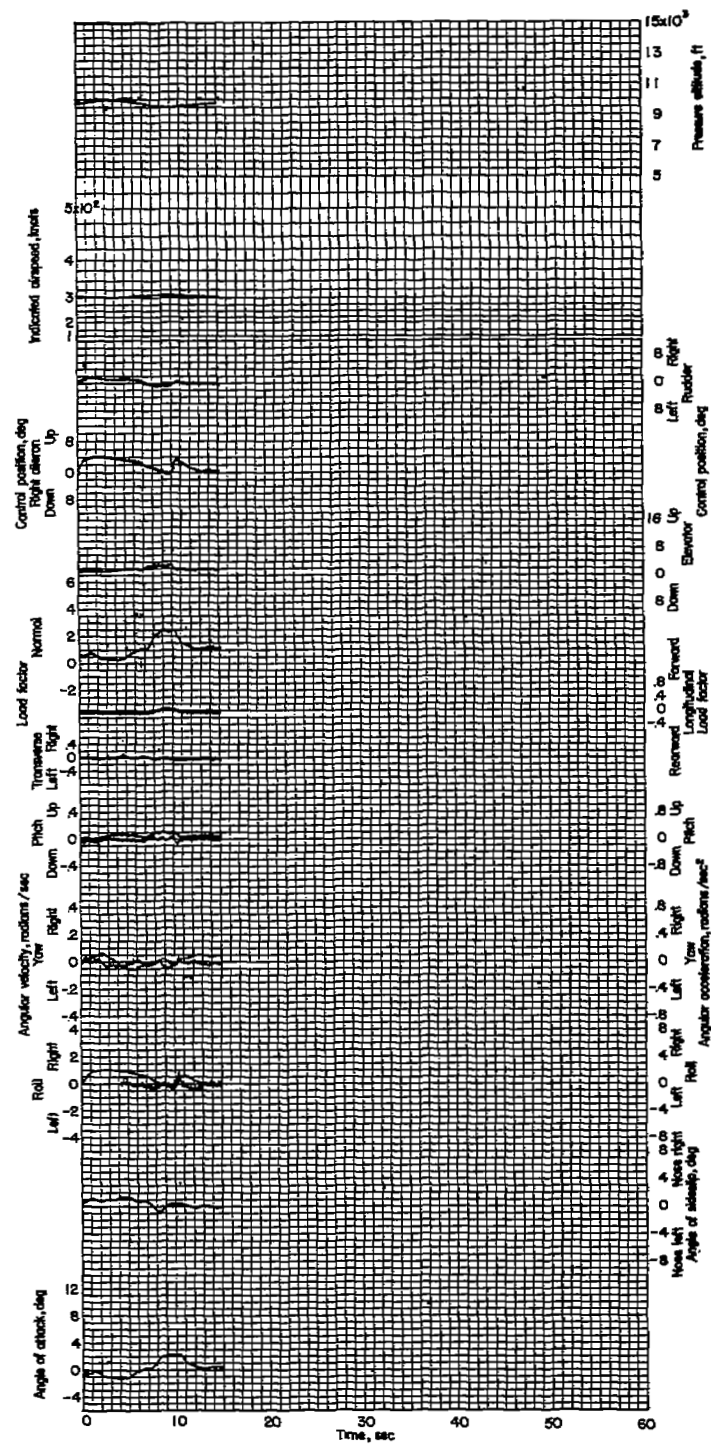


Figure 82.- Right aileron roll. Pilot A wearing anti-gravity suit; airplane weight, 12,070 pounds; center of gravity at 27.0 percent M.A.C.

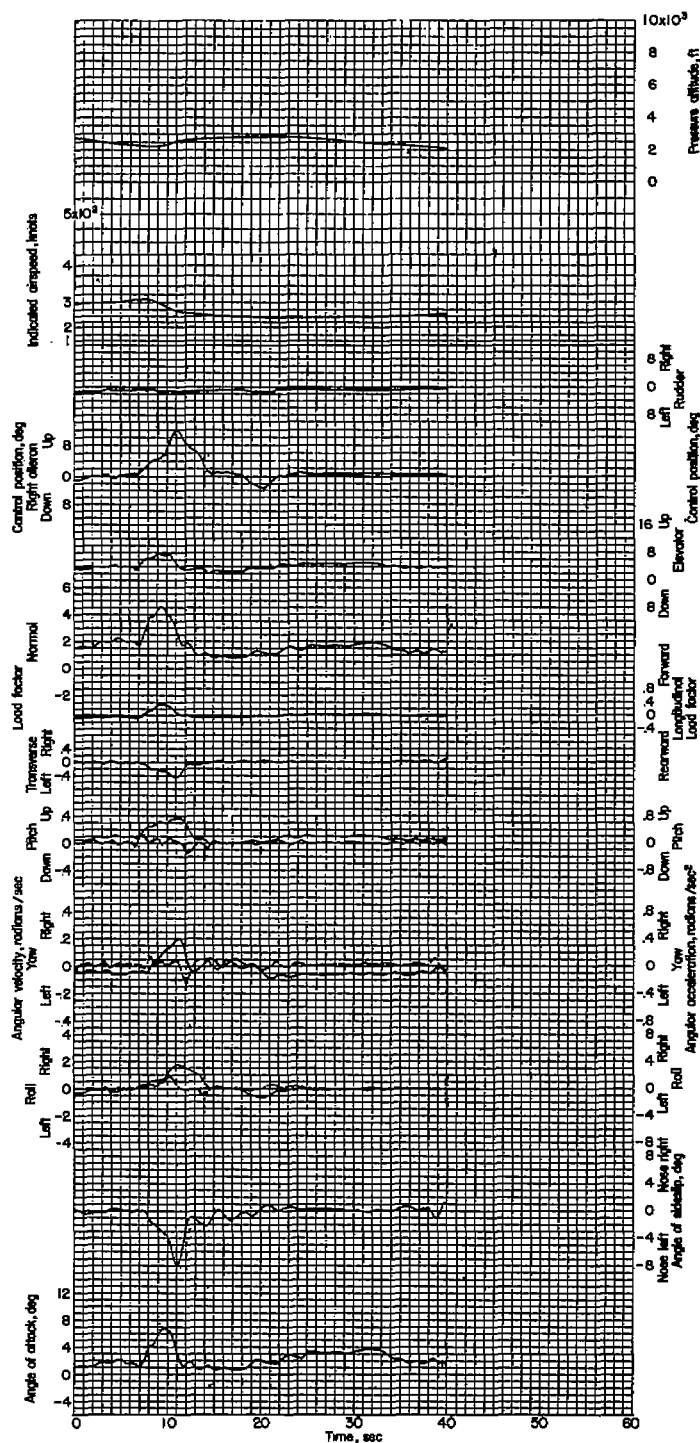


Figure 83.- Right aileron roll. Pilot D with radar observer; airplane weight, 12,190 pounds; center of gravity at 25.9 percent M.A.C.

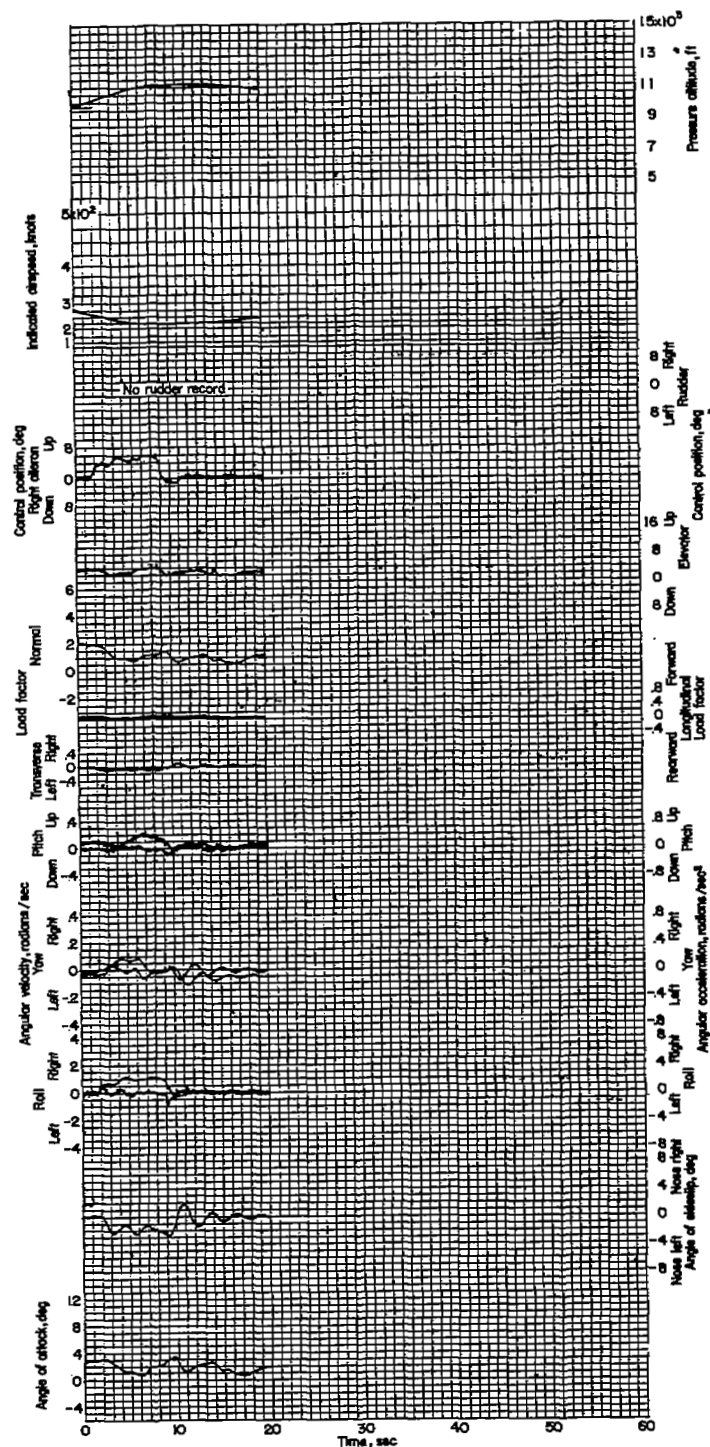


Figure 84.- Right aileron roll. Pilot G; airplane weight, 11,830 pounds; center of gravity at 26.5 percent M.A.C.

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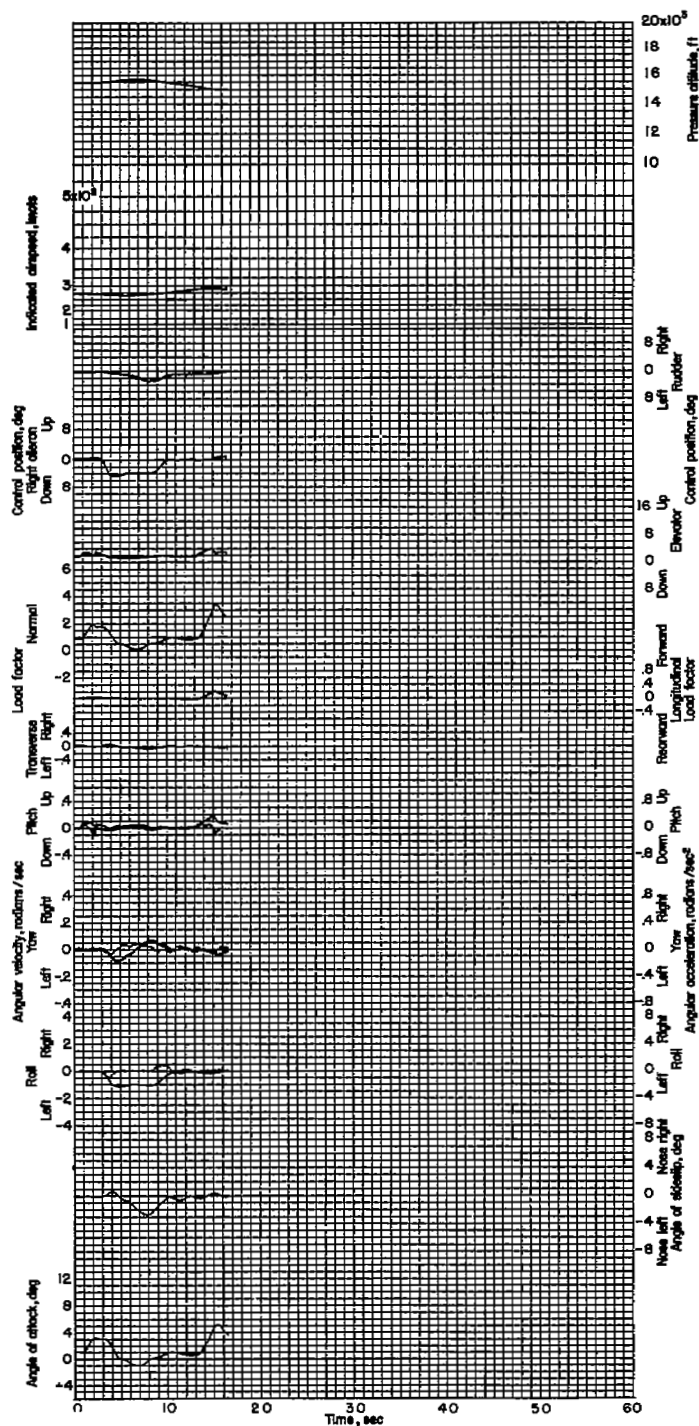
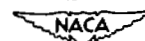


Figure 85.- Left aileron roll. Pilot A; airplane weight, 12,257 pounds; center of gravity at 27.4 percent M.A.C.



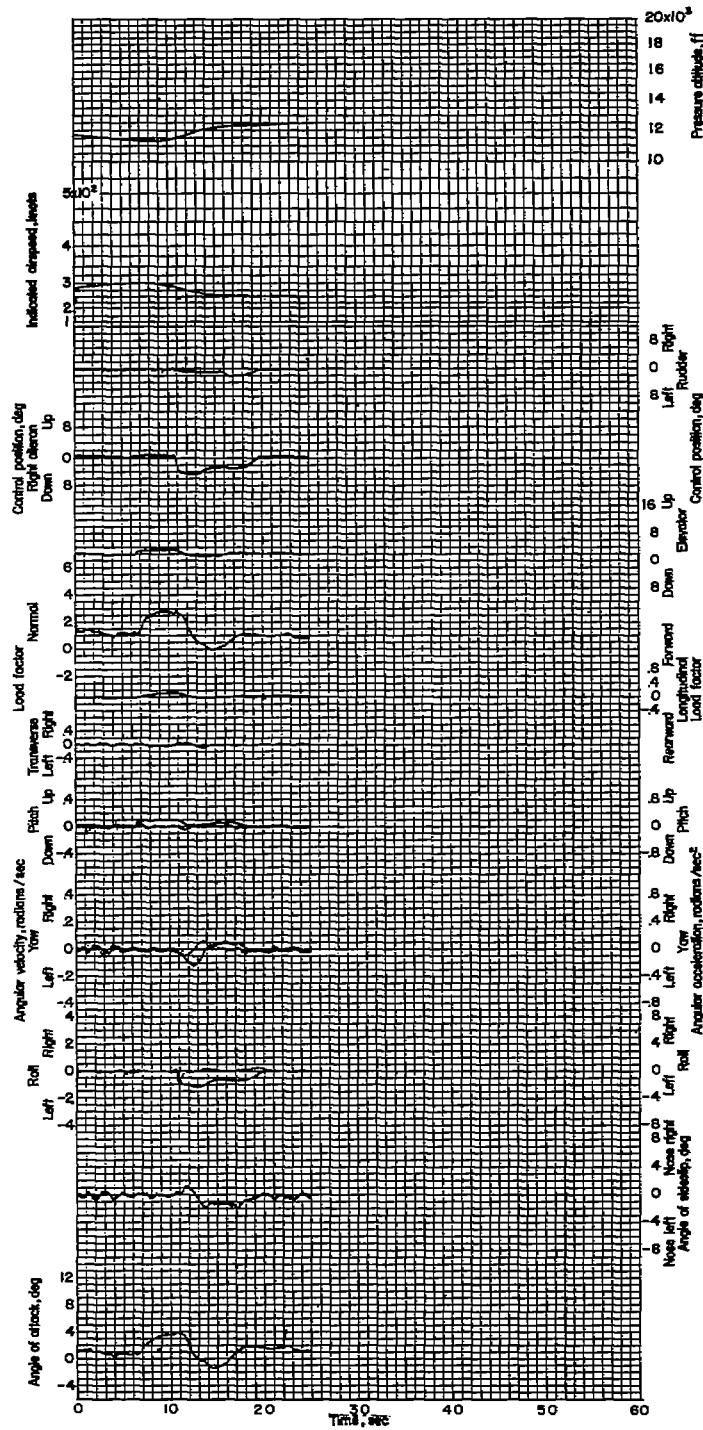


Figure 86.- Left aileron roll. Pilot A; airplane weight, 12,150 pounds; center of gravity at 27.2 percent M.A.C.



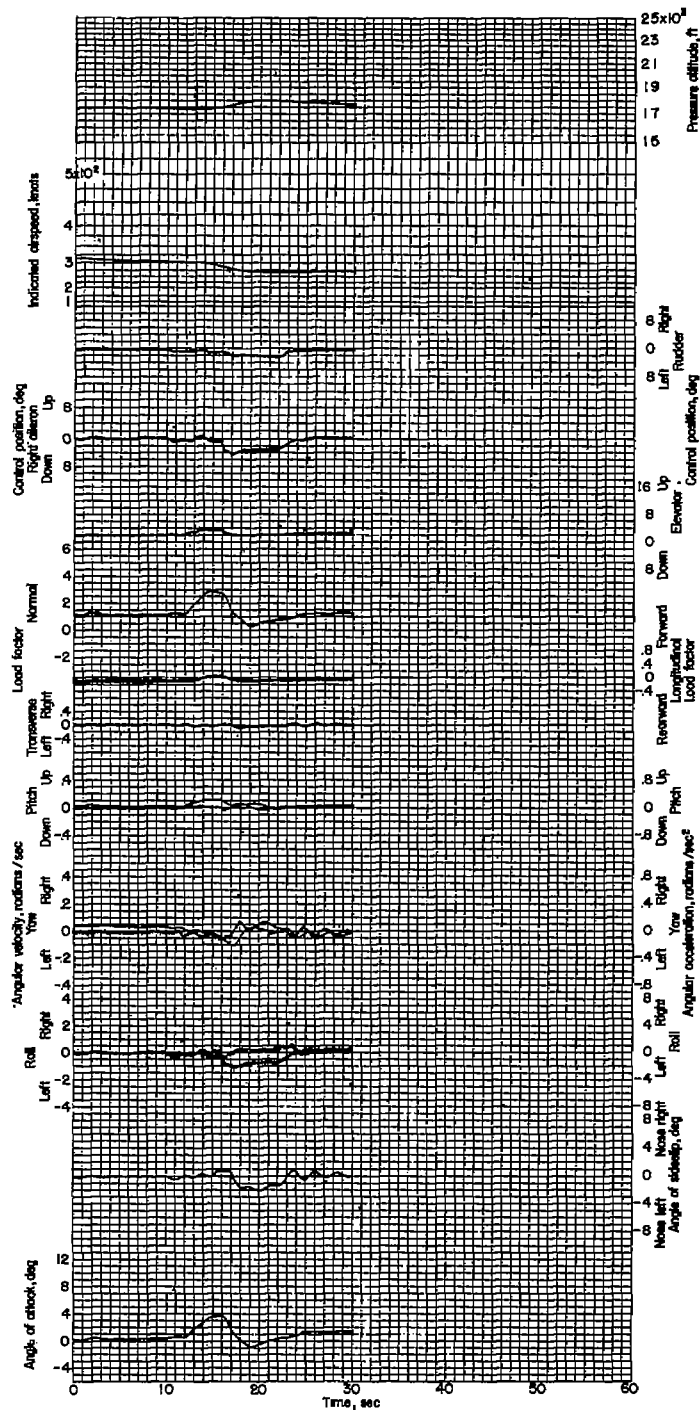


Figure 87.- Left aileron roll. Pilot A; airplane weight, 12,080 pounds; center of gravity at 27.1 percent M.A.C.

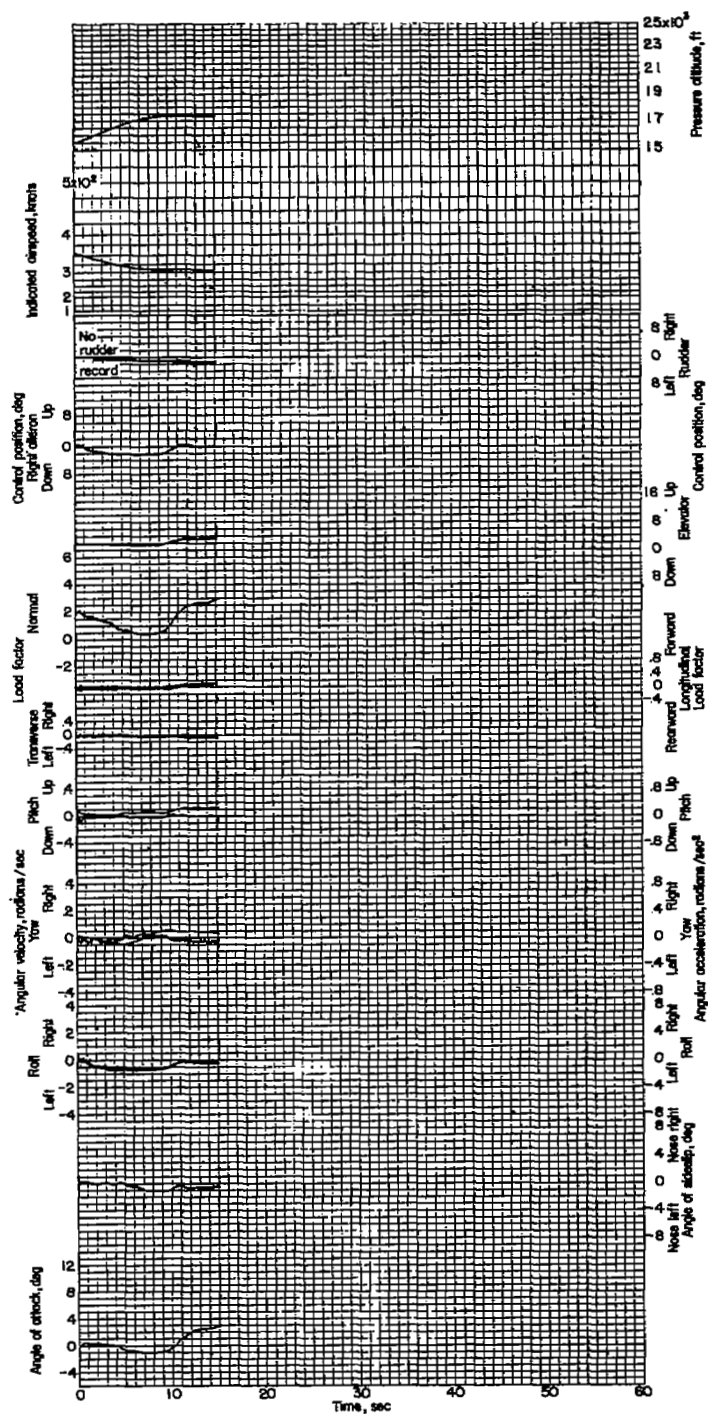


Figure 88.- Left aileron roll. Pilot A; airplane weight, 11,750 pounds; center of gravity at 26.4 percent M.A.C.

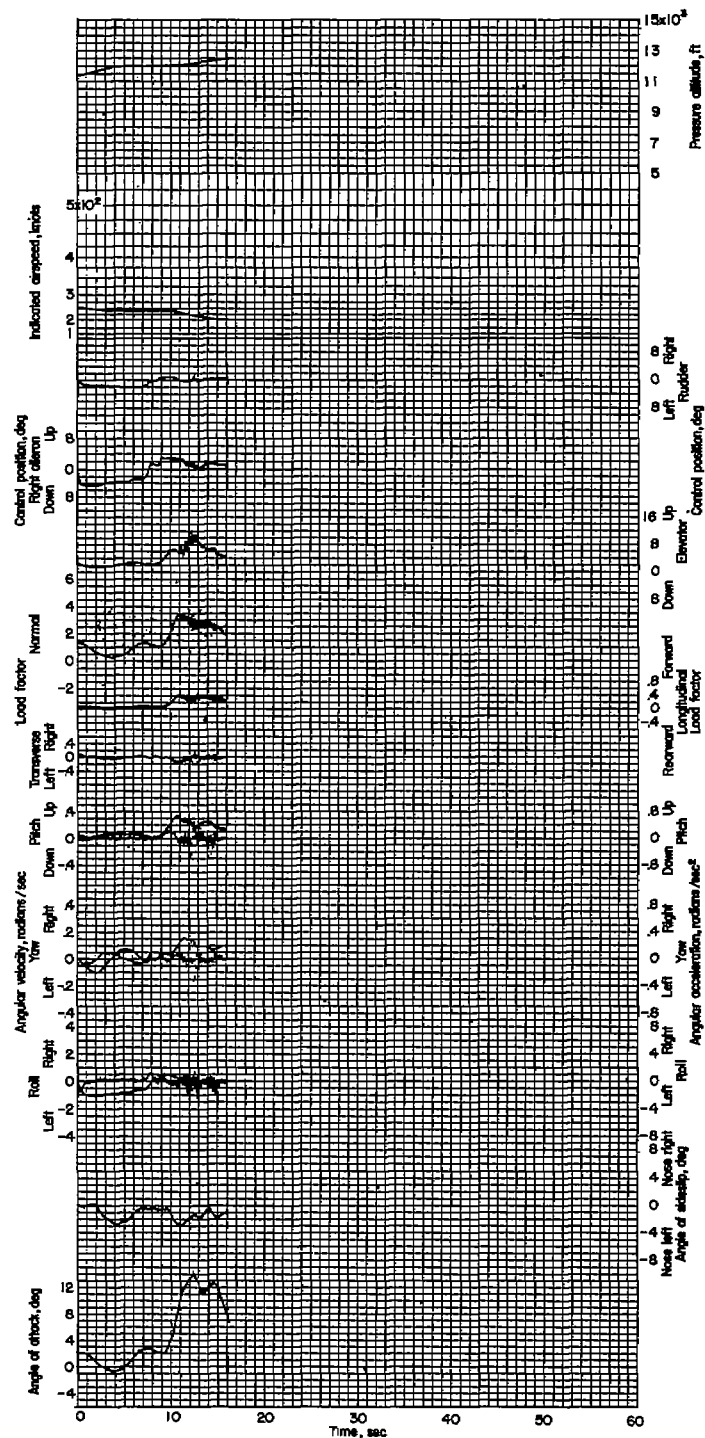


Figure 89.- Left aileron roll. Pilot A wearing anti-gravity suit; airplane weight, 12,320 pounds; center of gravity at 27.5 percent M.A.C.

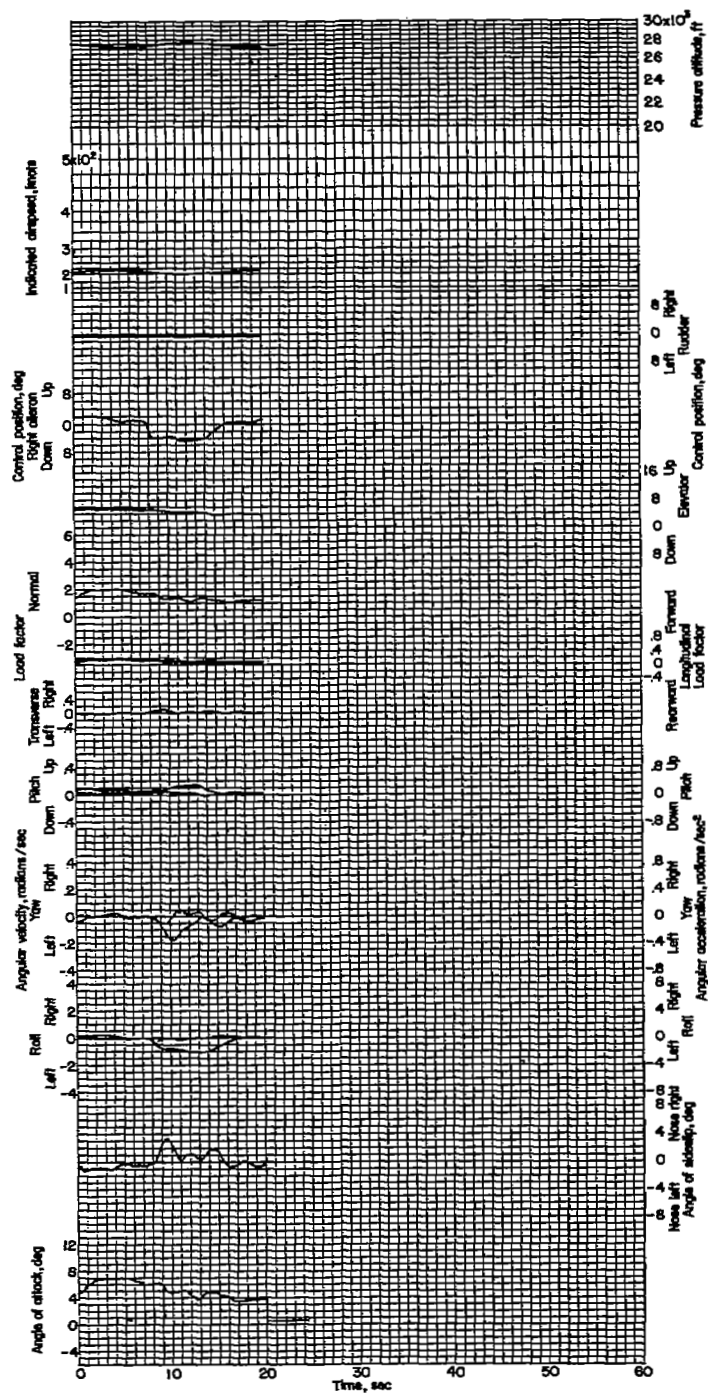


Figure 90.- Left aileron roll. Pilot B with radar observer; airplane weight, 12,180 pounds; center of gravity at 25.9 percent M.A.C.

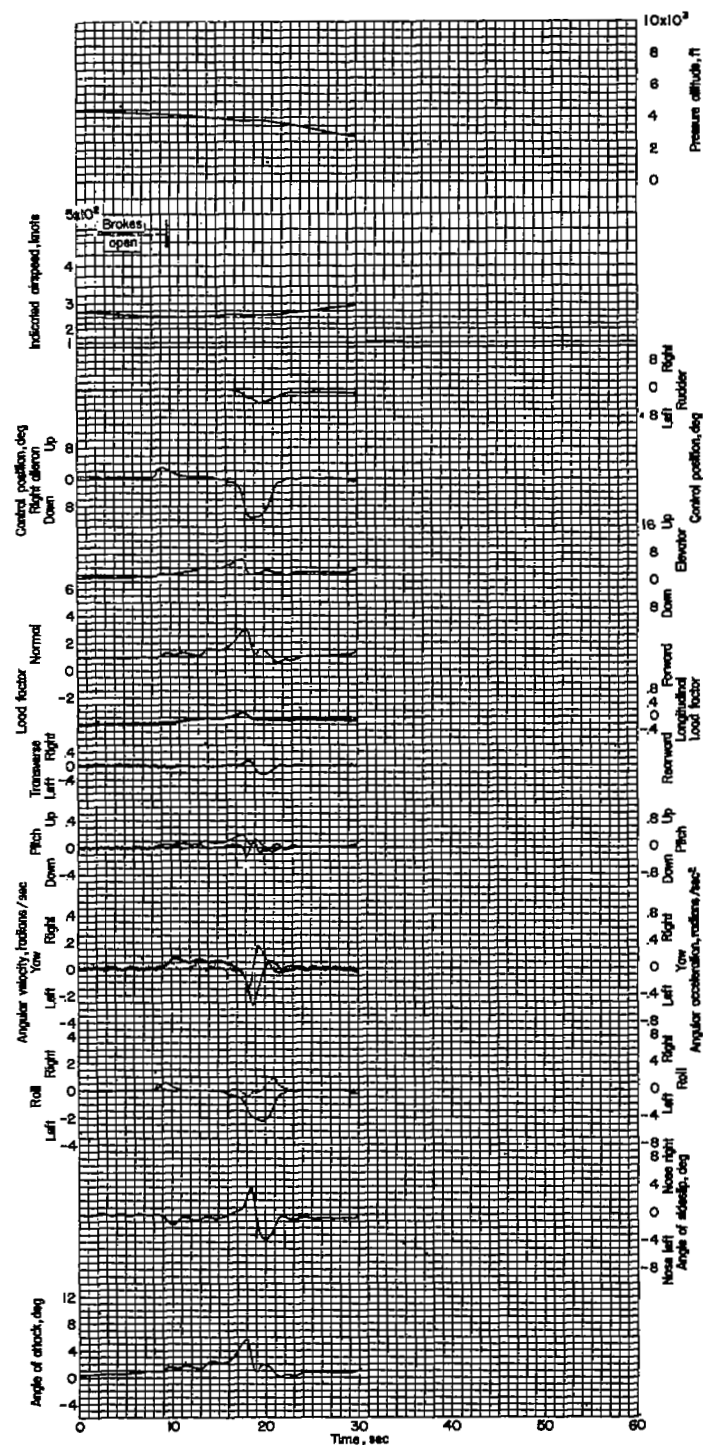


Figure 91.- Left aileron roll. Pilot D with radar observer; airplane weight, 12,230 pounds; center of gravity at 26.0 percent M.A.C.

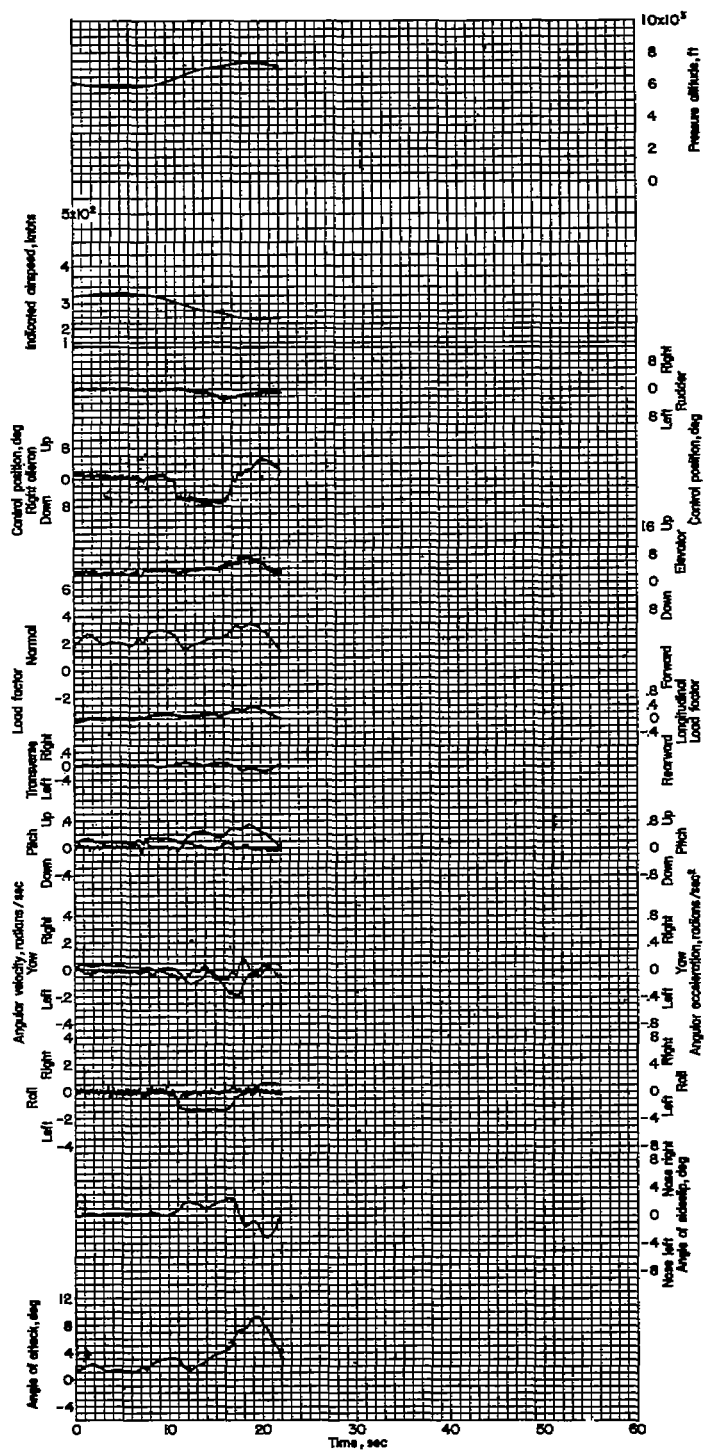


Figure 92.- Left aileron roll. Pilot G; airplane weight, 12,470 pounds; center of gravity at 27.8 percent M.A.C.



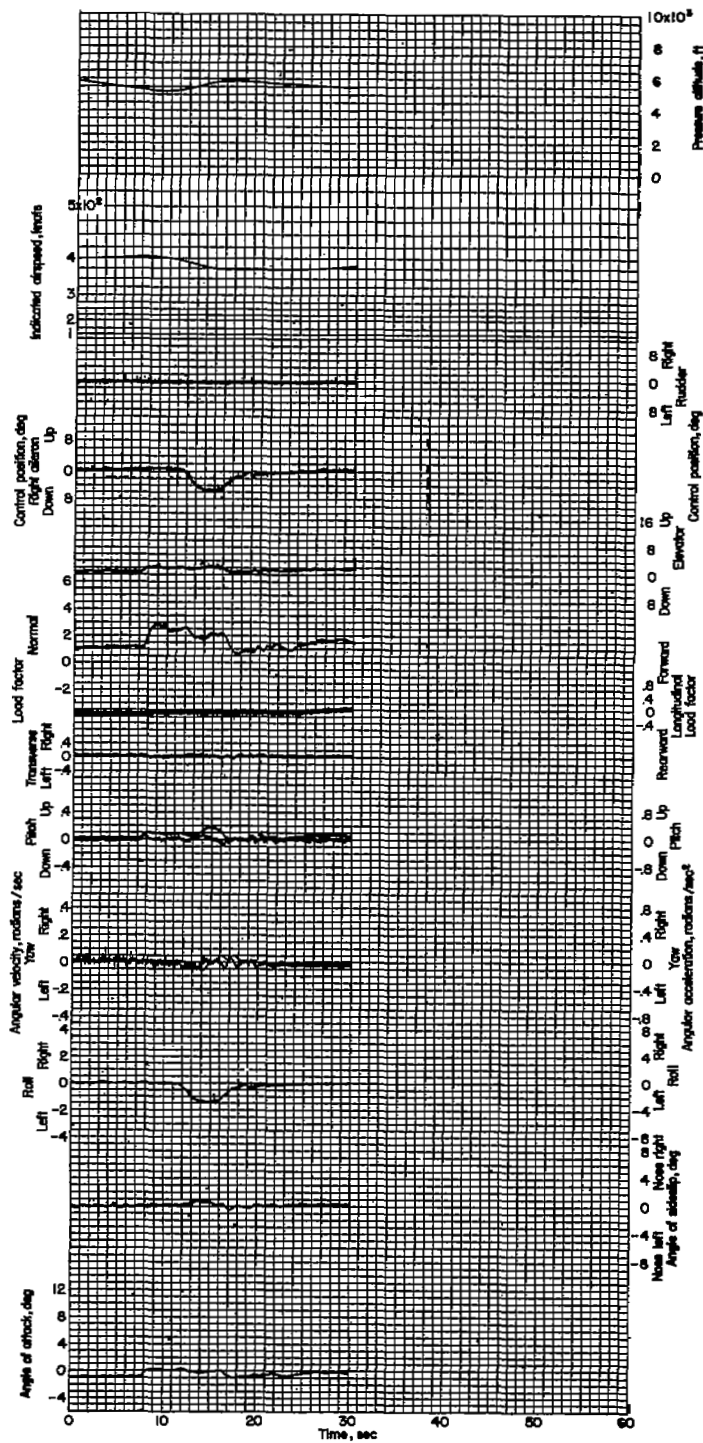


Figure 93.- Left aileron roll. Pilot G; airplane weight, 11,740 pounds; center of gravity at 26.4 percent M.A.C.



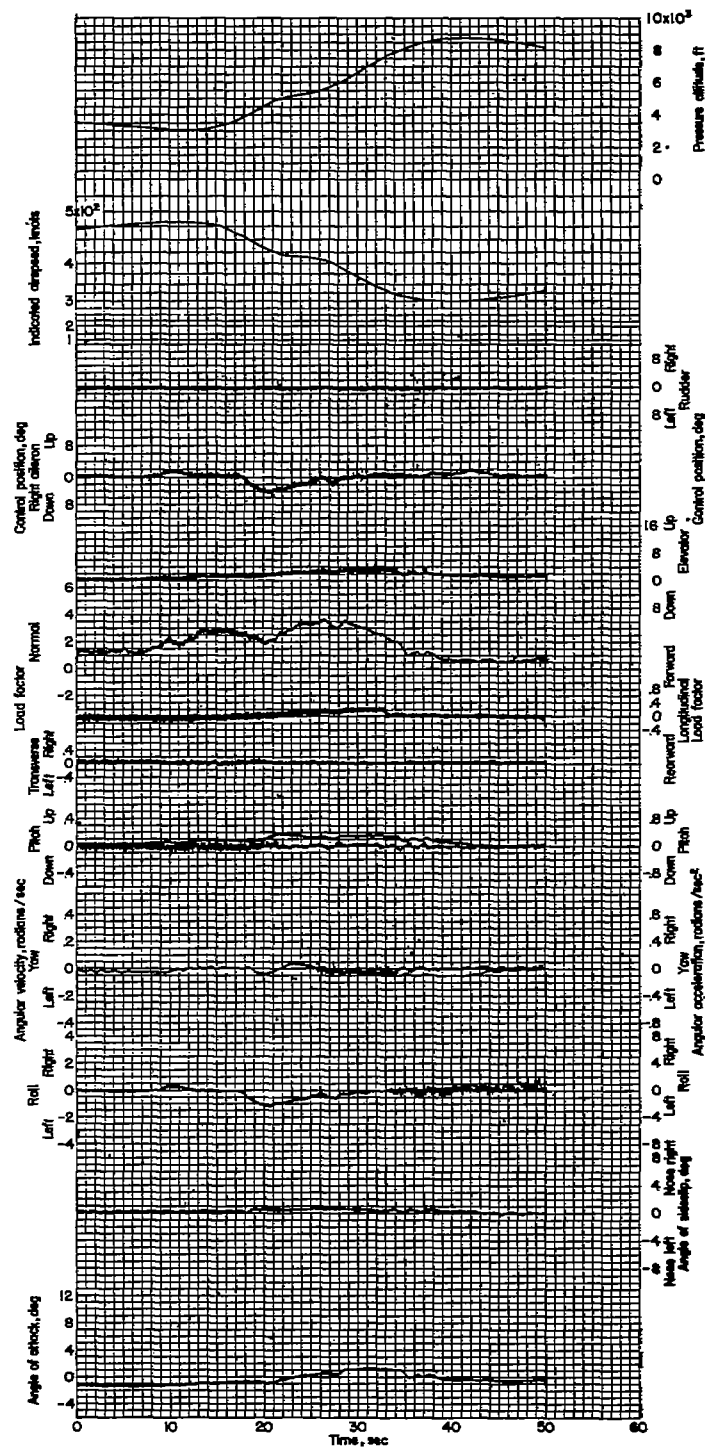


Figure 94.- Left aileron roll. Pilot G; airplane weight, 11,650 pounds; center of gravity at 26.2 percent M.A.C.



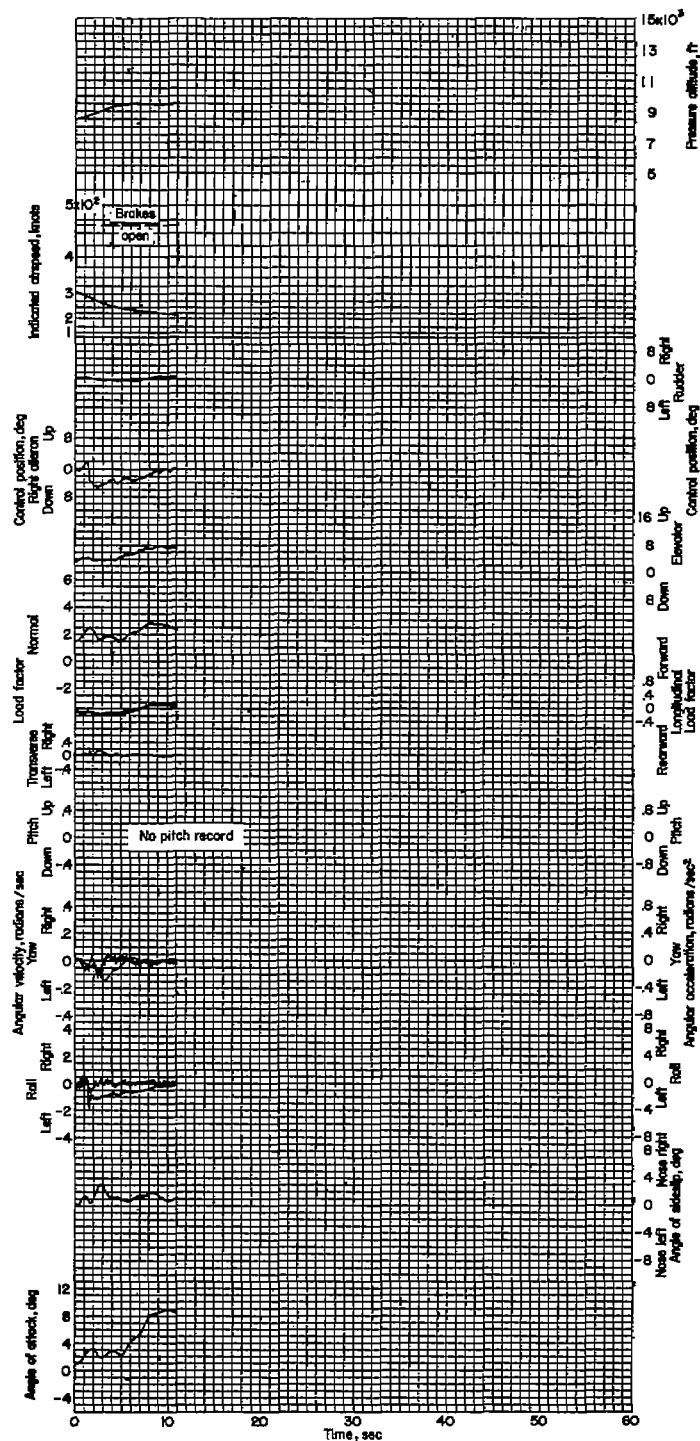


Figure 95.- Left aileron roll. Pilot G with radar observer; airplane weight, 12,230 pounds; center of gravity at 26.0 percent M.A.C.

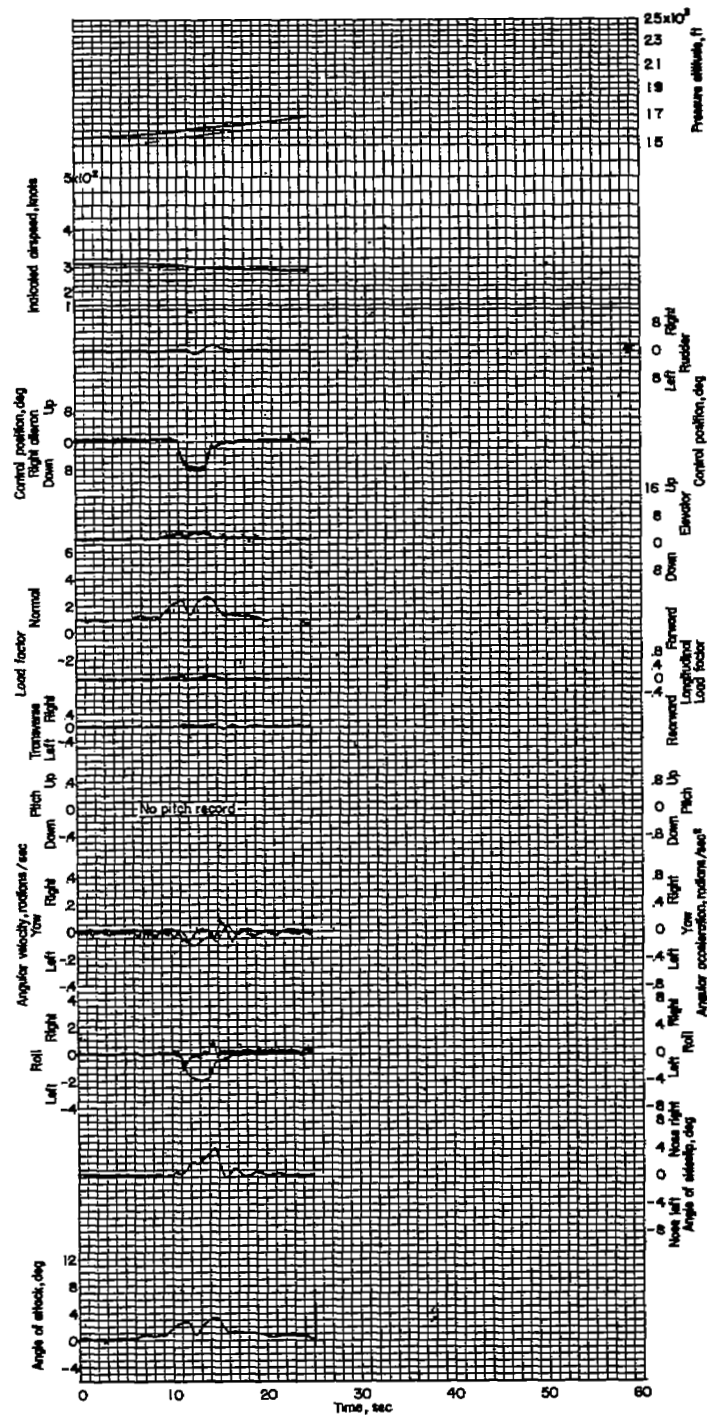


Figure 96.- Left aileron roll. Pilot G with radar observer; airplane weight, 13,000 pounds; center of gravity at 26.8 percent M.A.C.

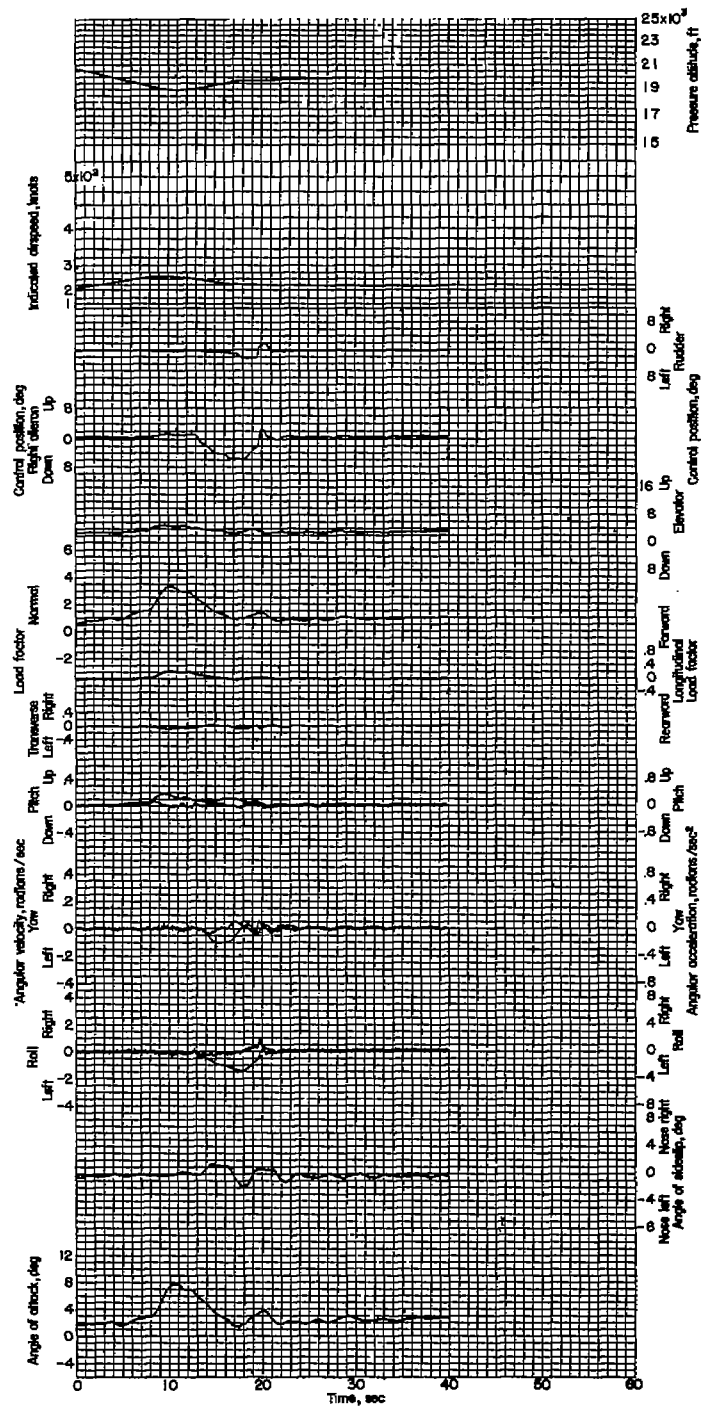


Figure 97.- Left aileron roll. Pilot H with radar observer; airplane weight, 12,580 pounds; center of gravity at 26.7 percent M.A.C.

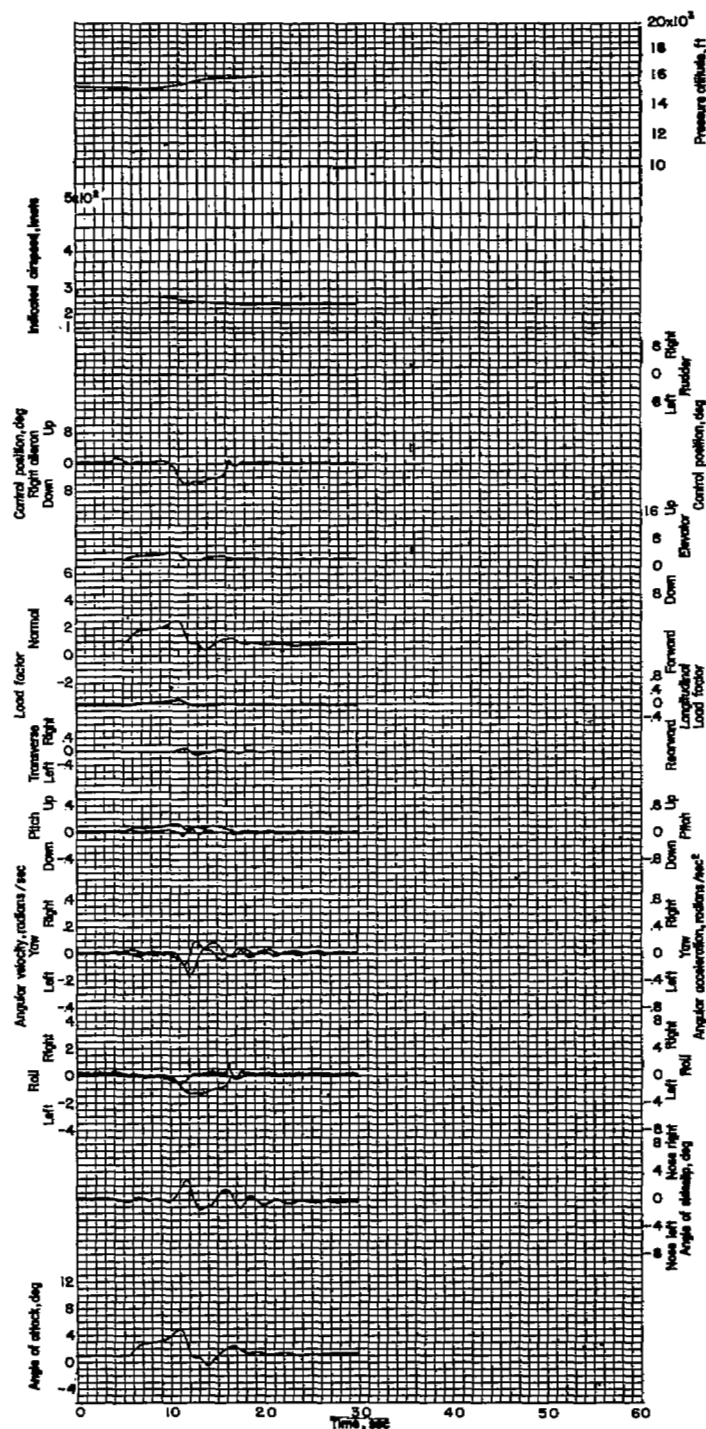


Figure 98.- Left aileron roll. Pilot H with radar observer; airplane weight, 12,240 pounds; center of gravity at 26.0 percent M.A.C.

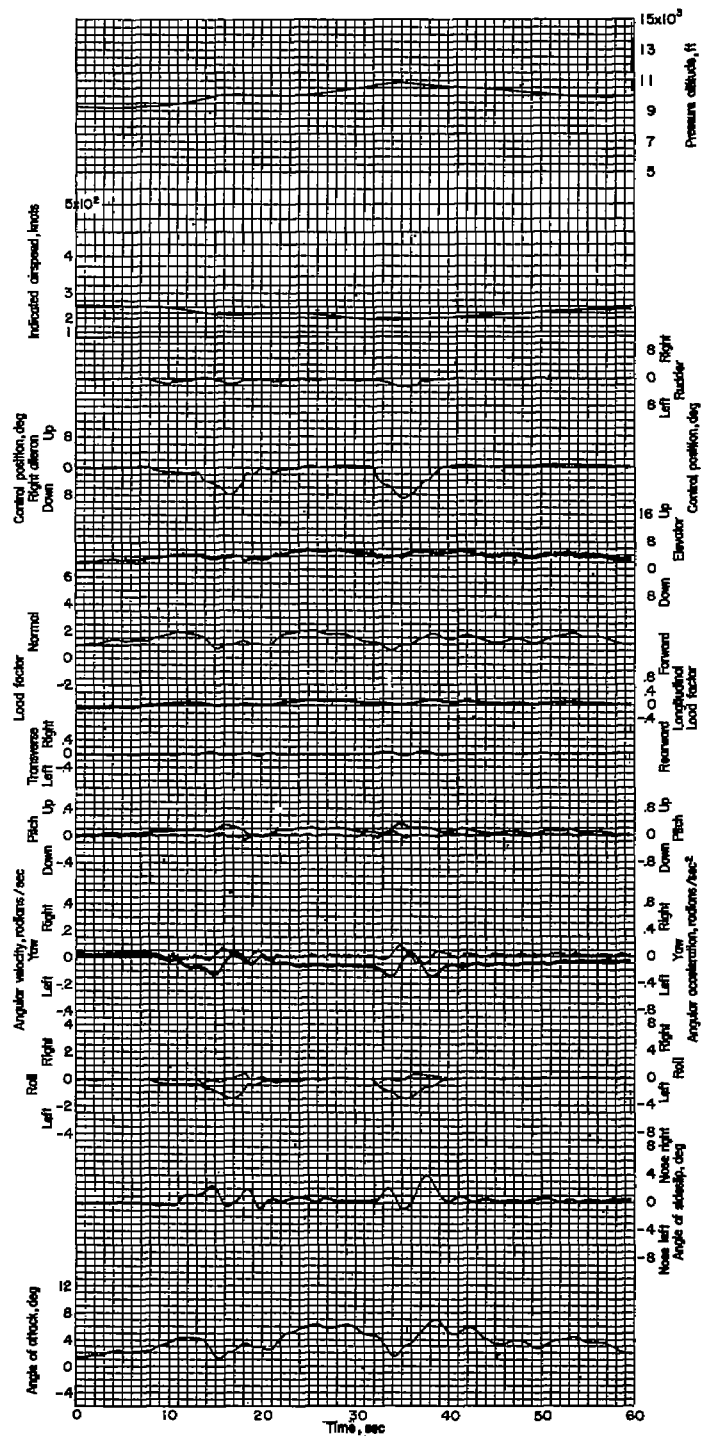


Figure 99.- Two left aileron rolls. Pilot C with radar observer; airplane weight, 11,920 pounds; center of gravity 25.4 percent M.A.C.



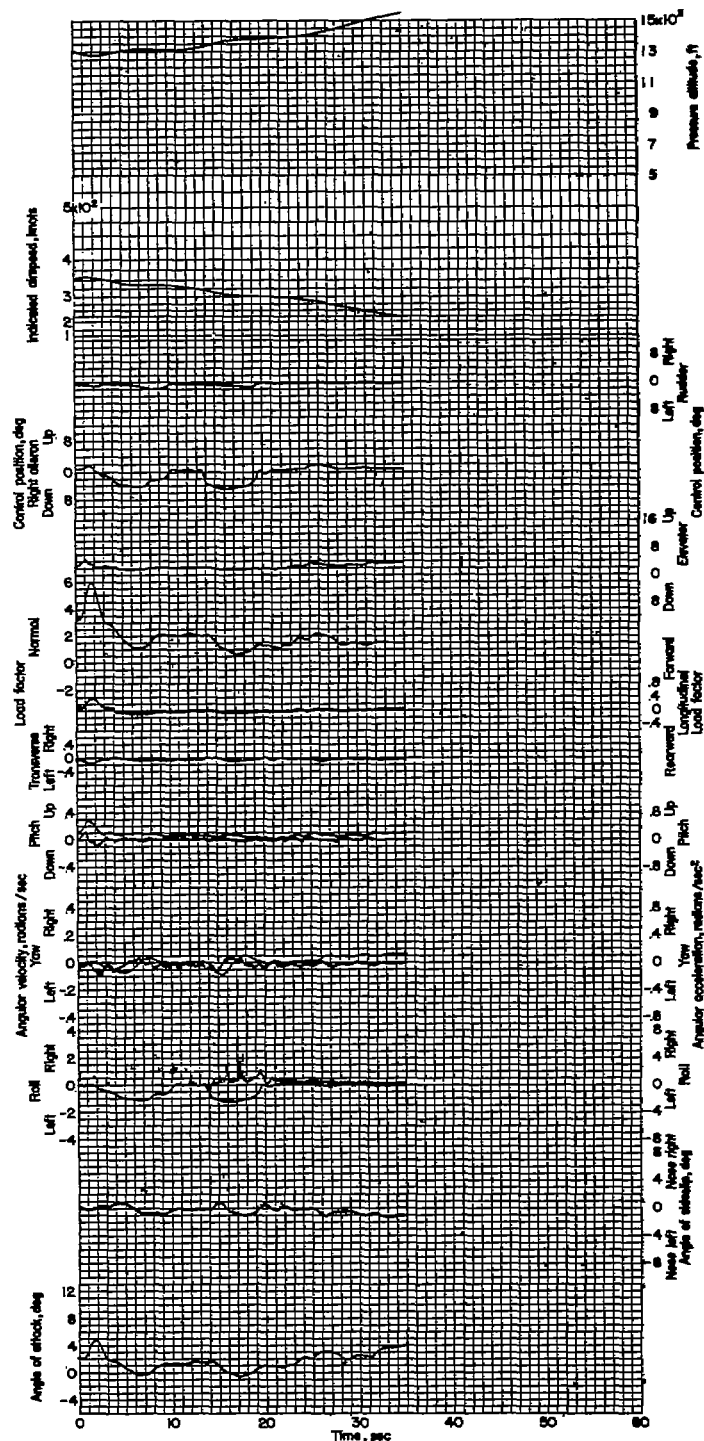


Figure 100.- Two left aileron rolls. Pilot H with radar observer; airplane weight, 12,380 pounds; center of gravity at 26.3 percent M.A.C.

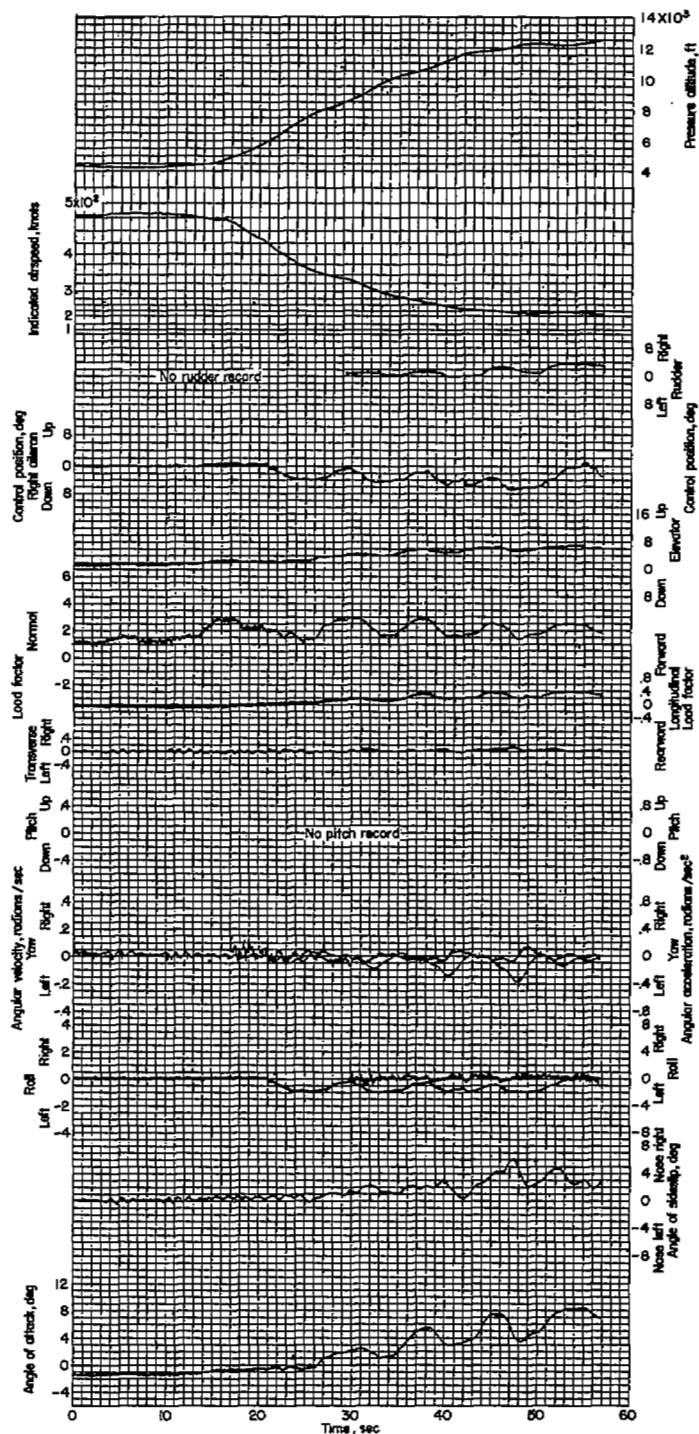


Figure 101.- Four left aileron rolls. Pilot G with radar observer; air-plane weight, 12,300 pounds; center of gravity at 26.2 percent M.A.C.

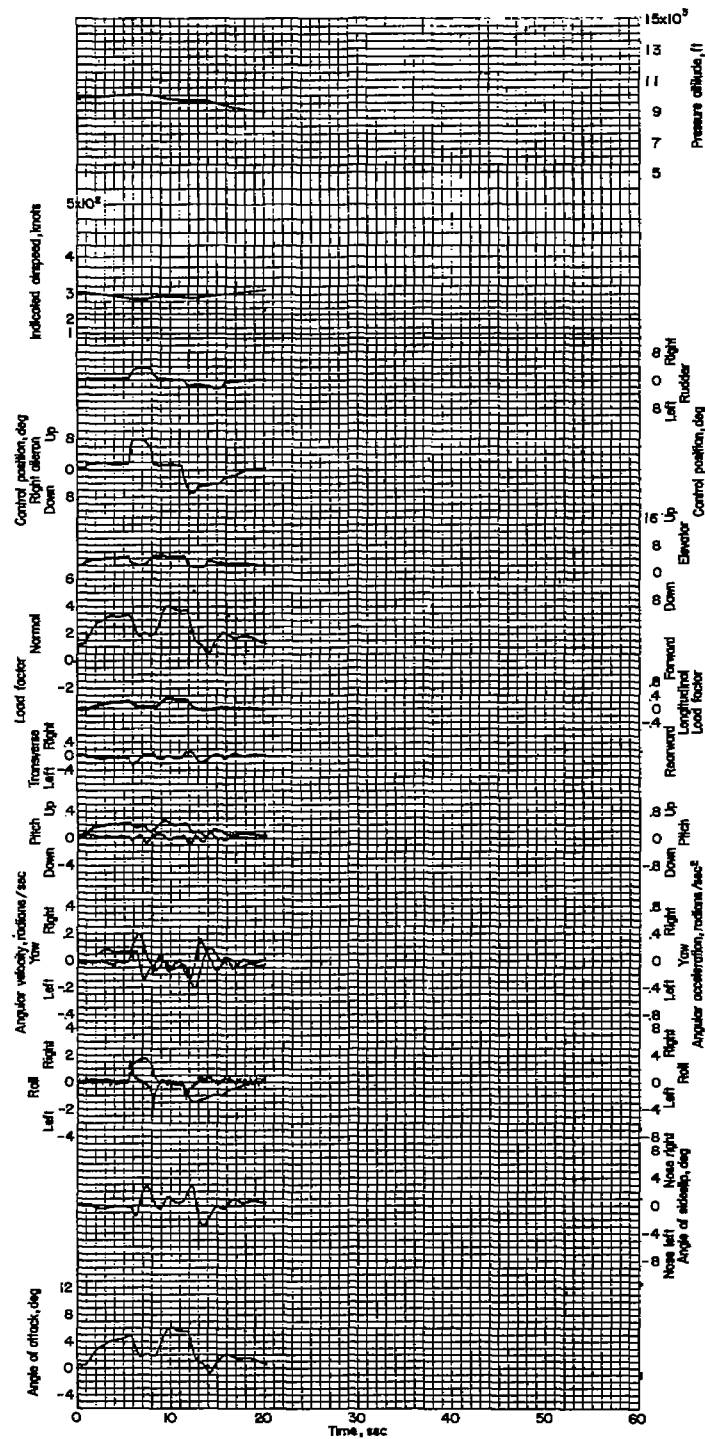


Figure 102.- Right and left half-aileron rolls. Pilot A wearing anti-gravity suit; airplane weight, 12,050 pounds; center of gravity at 27.0 percent M.A.C.

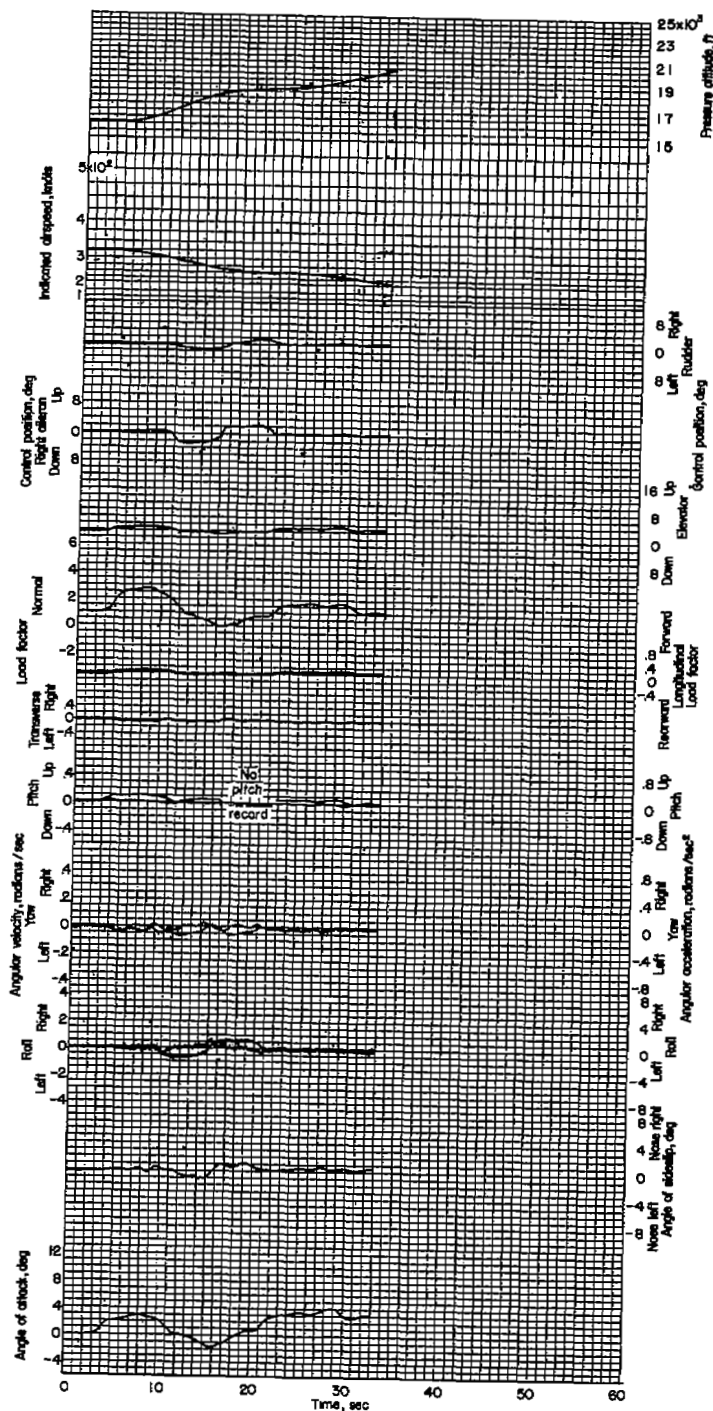


Figure 103.- Left and right half-aileron rolls. Pilot A; airplane weight, 11,930 pounds; center of gravity at 26.8 percent M.A.C.

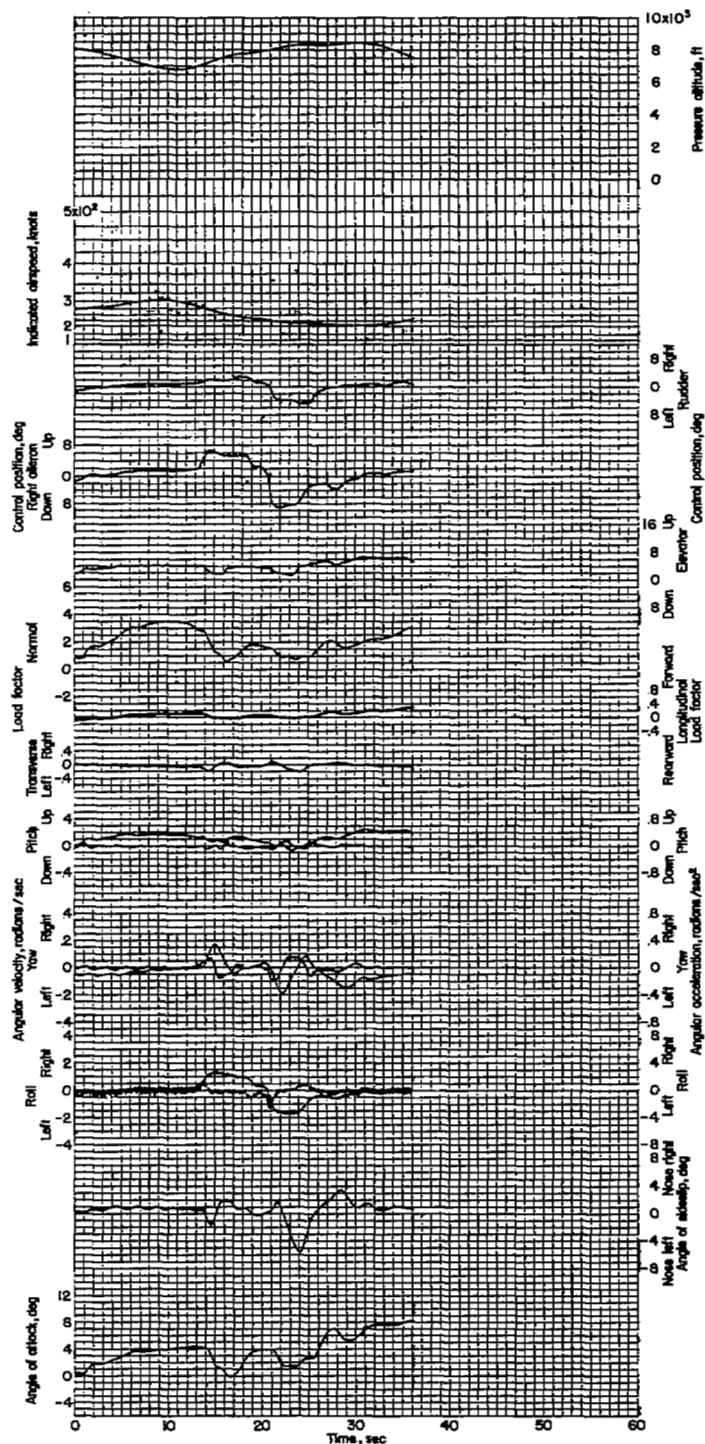


Figure 104.- Right and left aileron roll. Pilot A; airplane weight, 11,550 pounds; center of gravity at 26.0 percent M.A.C.

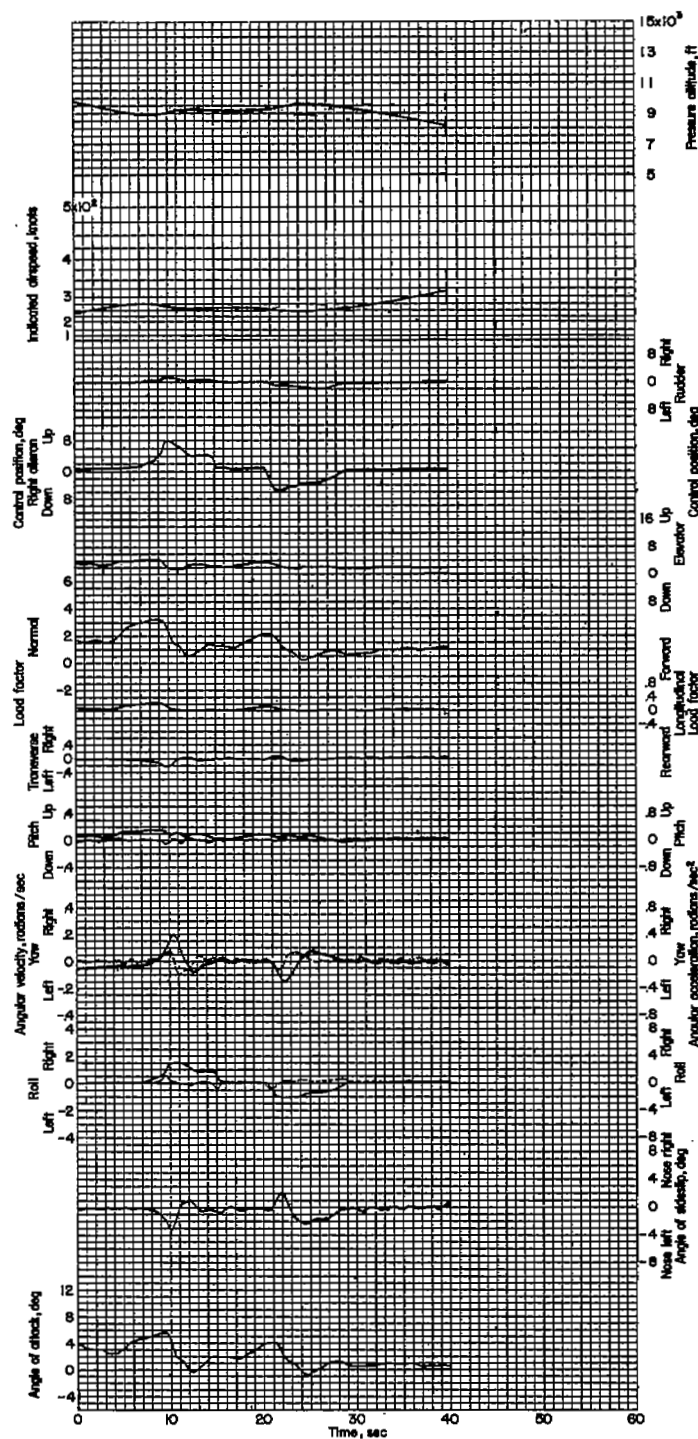


Figure 105.- Right and left aileron roll. Pilot A; airplane weight, 12,000 pounds; center of gravity at 26.9 percent M.A.C.

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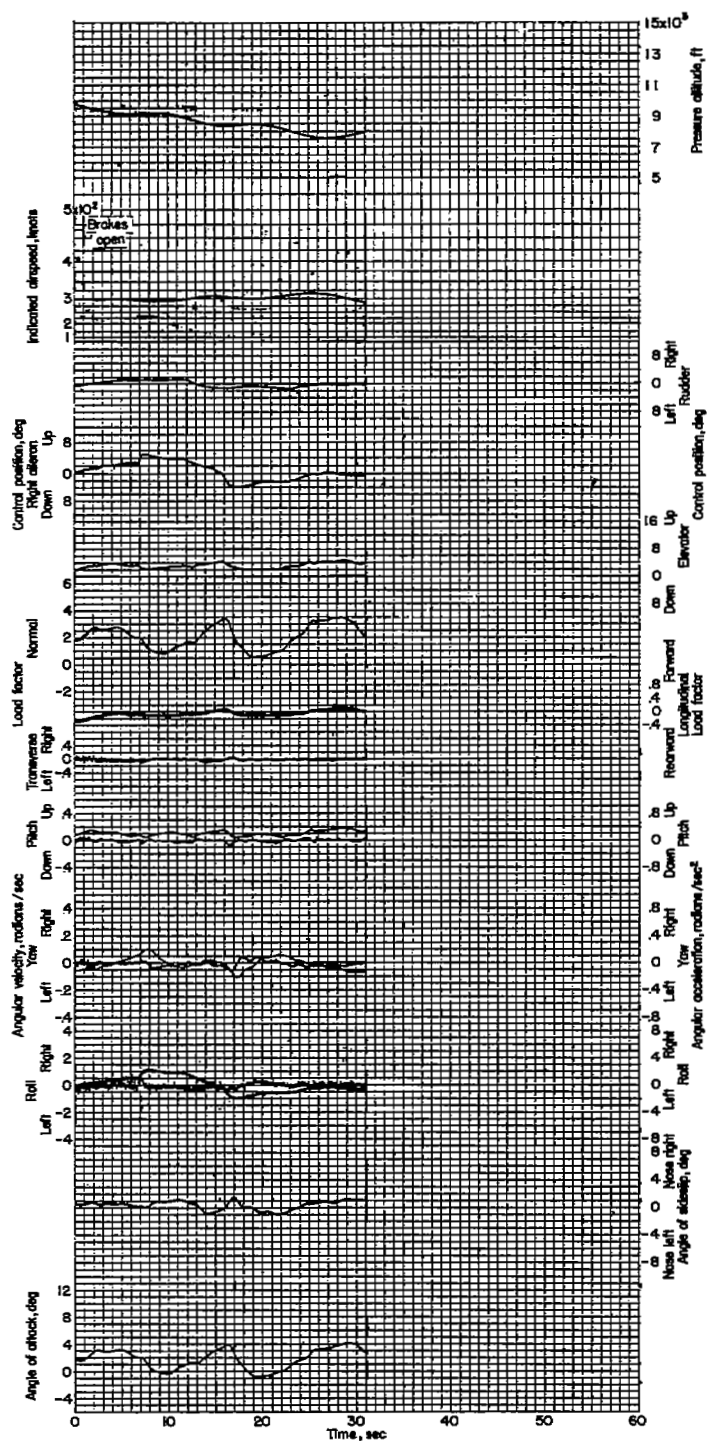


Figure 106.- Right and left aileron roll. Pilot A; airplane weight, 11,590 pounds; center of gravity at 26.1 percent M.A.C.



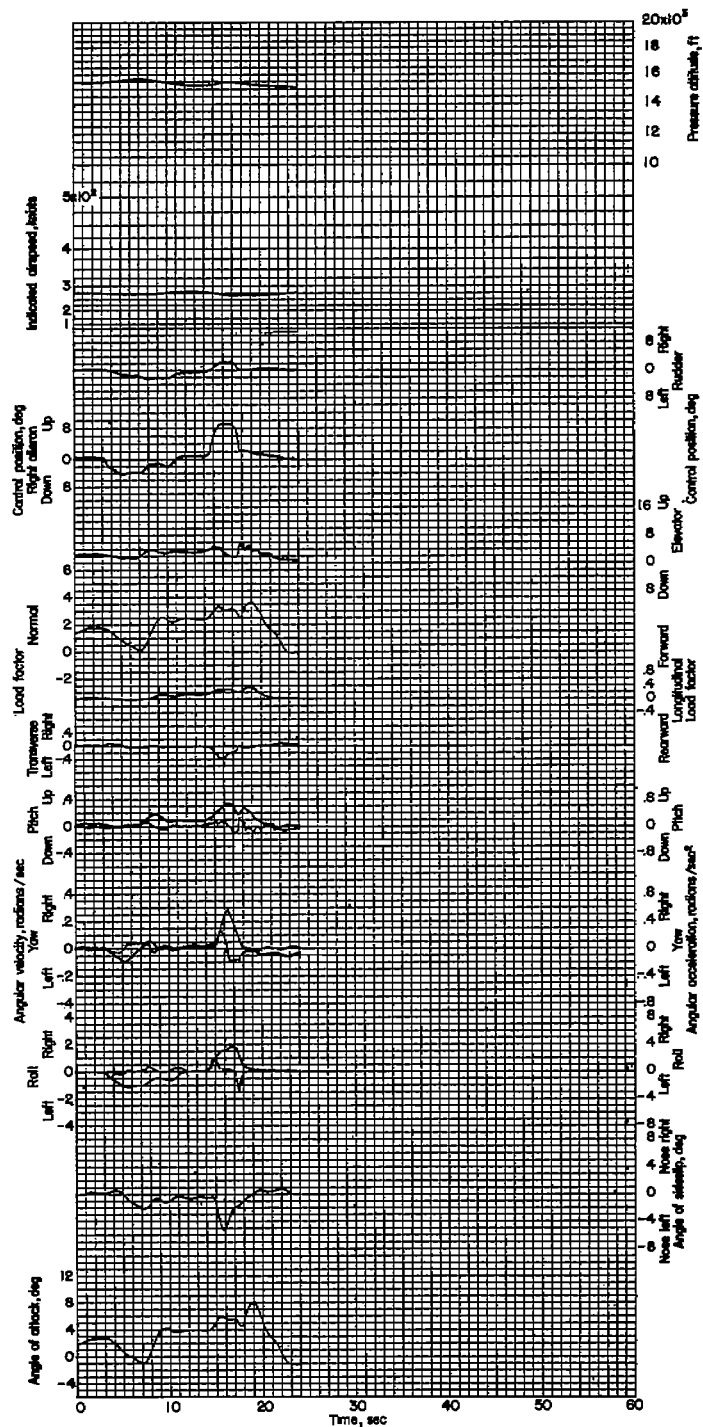


Figure 107.- Left and right aileron roll. Pilot A; airplane weight, 12,245 pounds; center of gravity at 27.4 percent M.A.C.



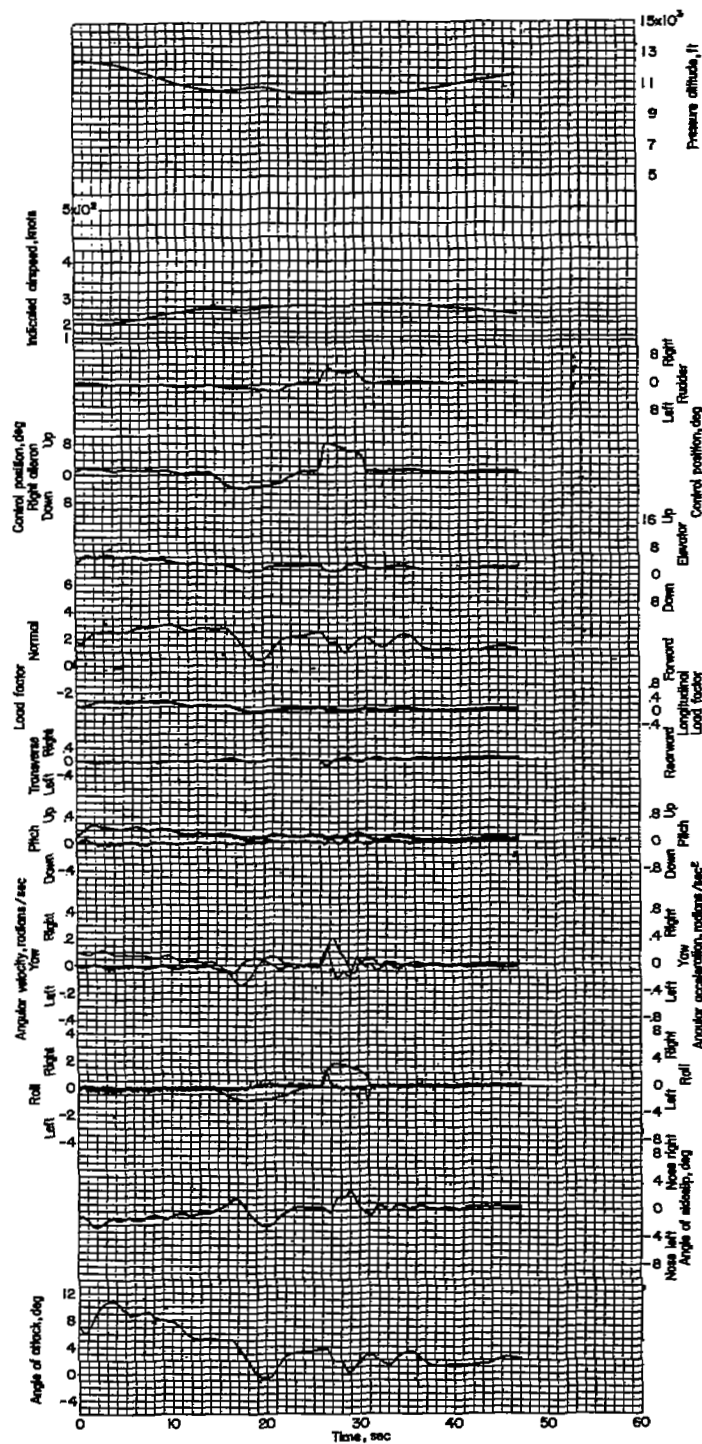


Figure 108.- Left and right aileron roll. Pilot A wearing anti-gravity suit; airplane weight, 12,290 pounds; center of gravity at 27.4 percent M.A.C.

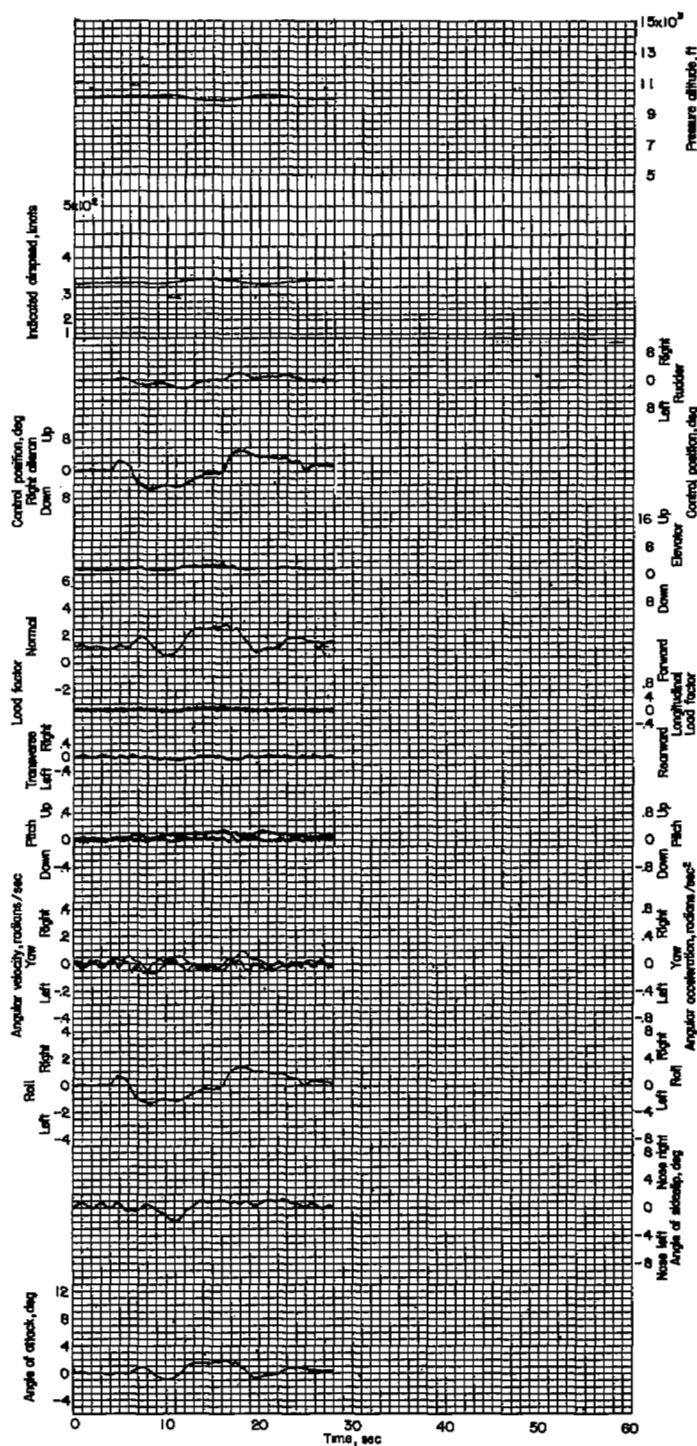


Figure 109.- Left and right aileron roll. Pilot A wearing anti-gravity suit; airplane weight, 12,130 pounds; center of gravity at 27.1 percent M.A.C.

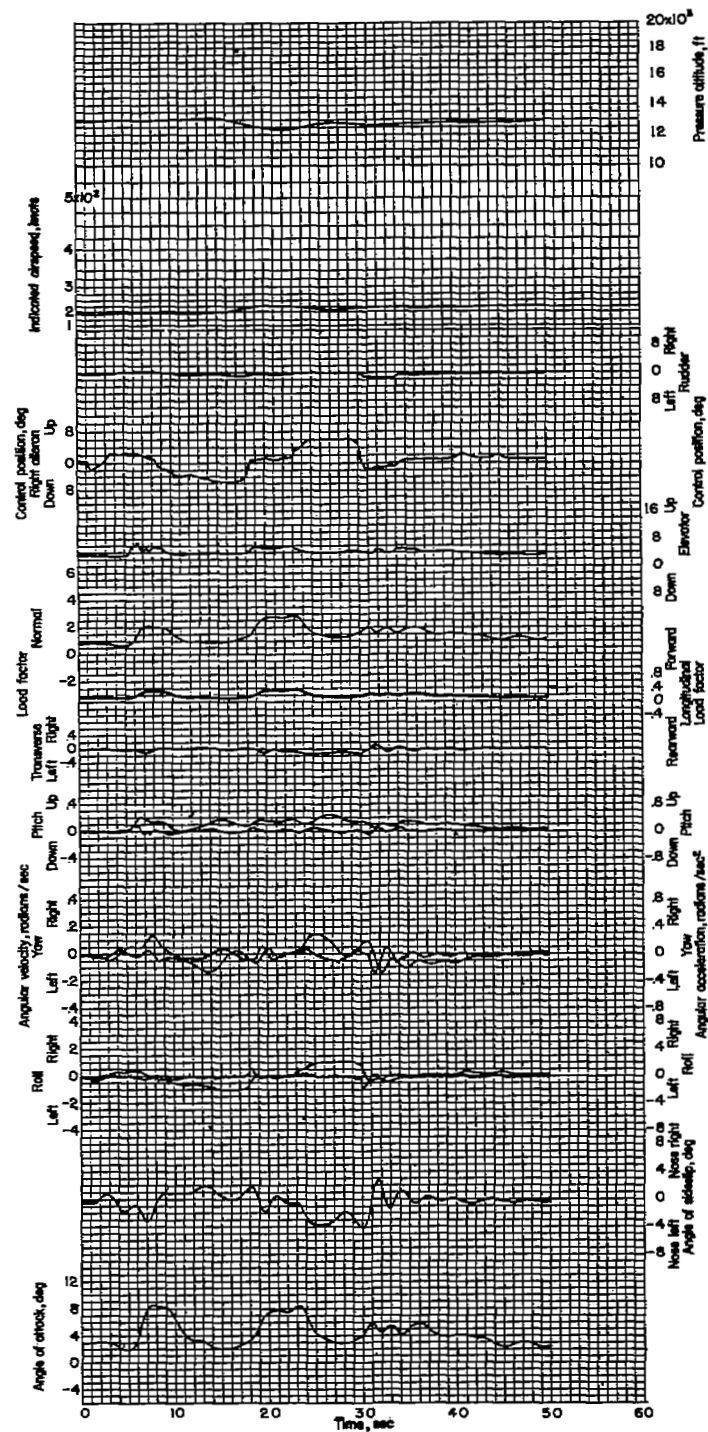


Figure 110.- Left and right aileron roll. Pilot F wearing anti-gravity suit; airplane weight, 11,950 pounds; center of gravity at 26.8 percent M.A.C.

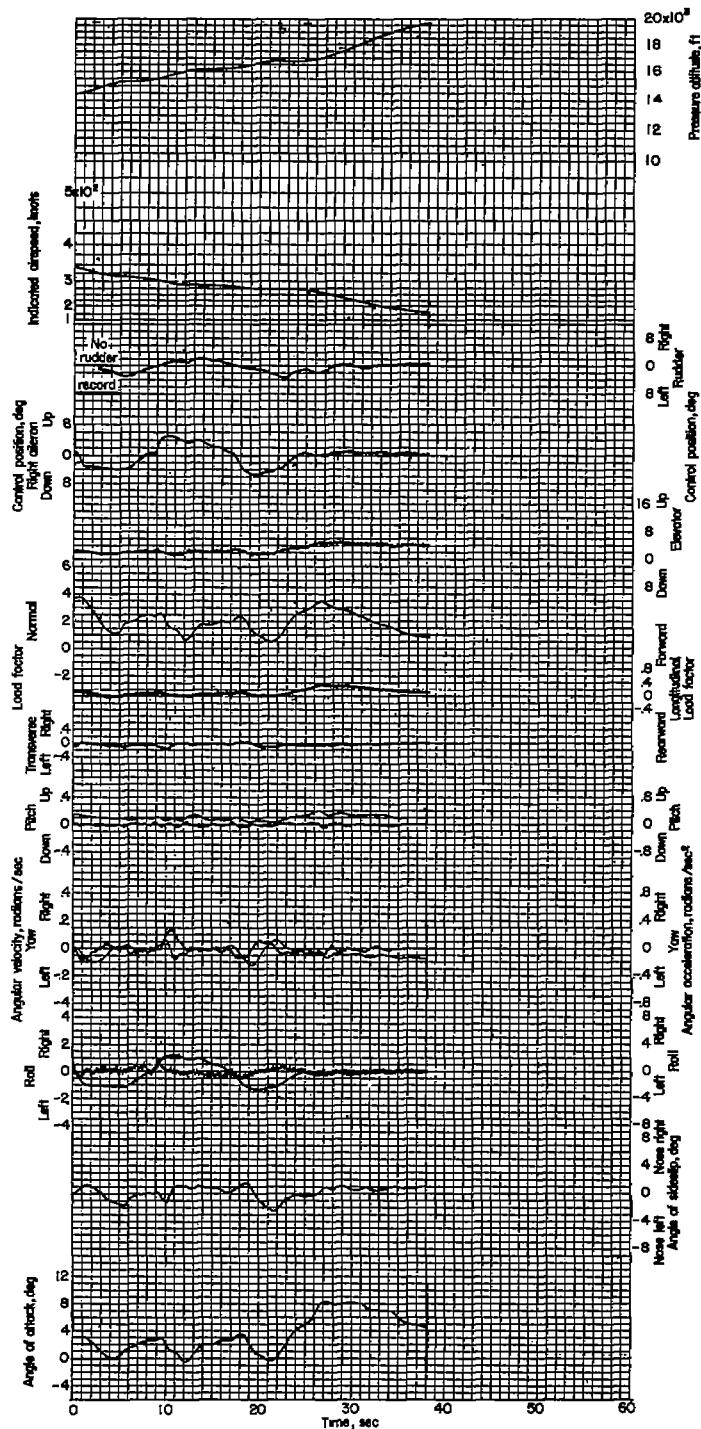


Figure 111.- Left, right, and left aileron roll. Pilot A; airplane weight, 12,365 pounds; center of gravity at 27.6 percent M.A.C.

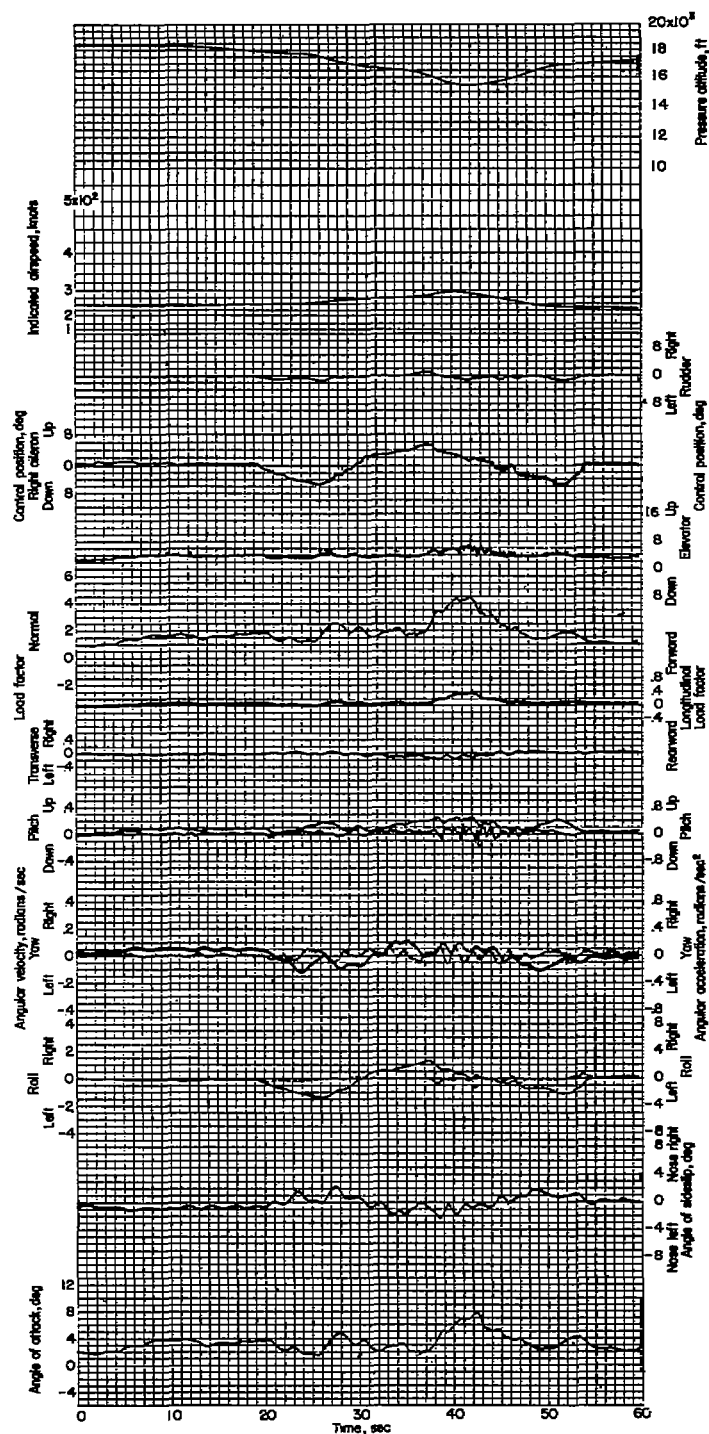


Figure 112.- Left, right, and left aileron roll. Pilot C with radar observer; airplane weight, 12,360 pounds; center of gravity at 26.0 percent M.A.C.

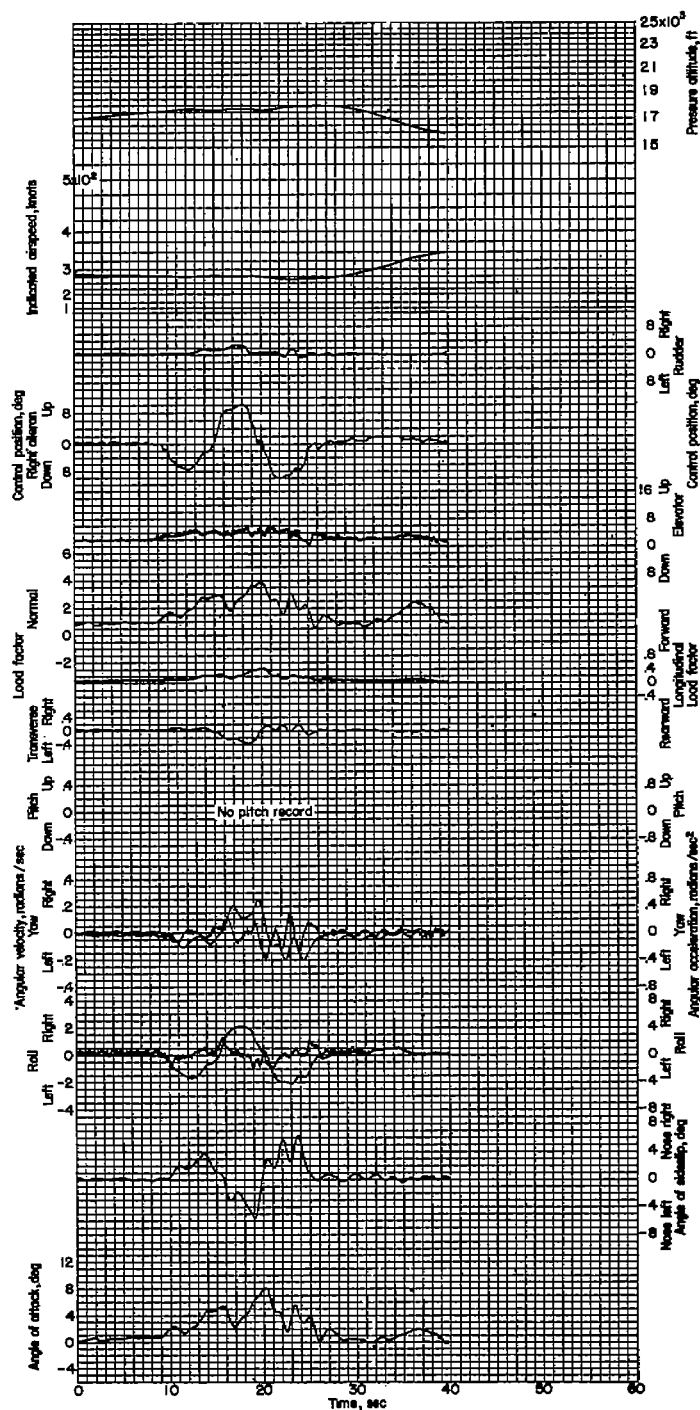


Figure 113.- Left, right, and left aileron roll. Pilot G with radar observer; airplane weight, 12,980 pounds; center of gravity at 26.9 percent M.A.C.



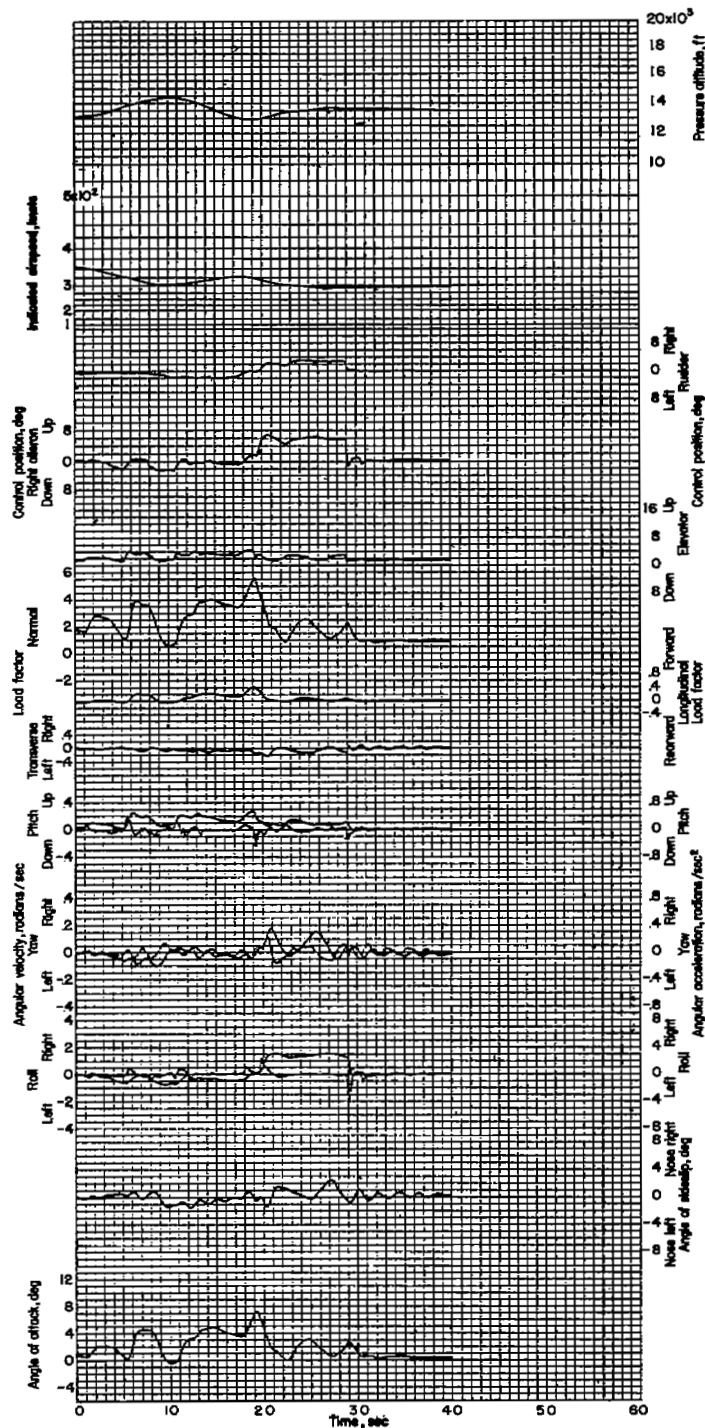


Figure 114.- Three-part left aileron roll followed by two consecutive right aileron rolls. Pilot A; airplane weight, 12,510 pounds; center of gravity at 27.8 percent M.A.C.

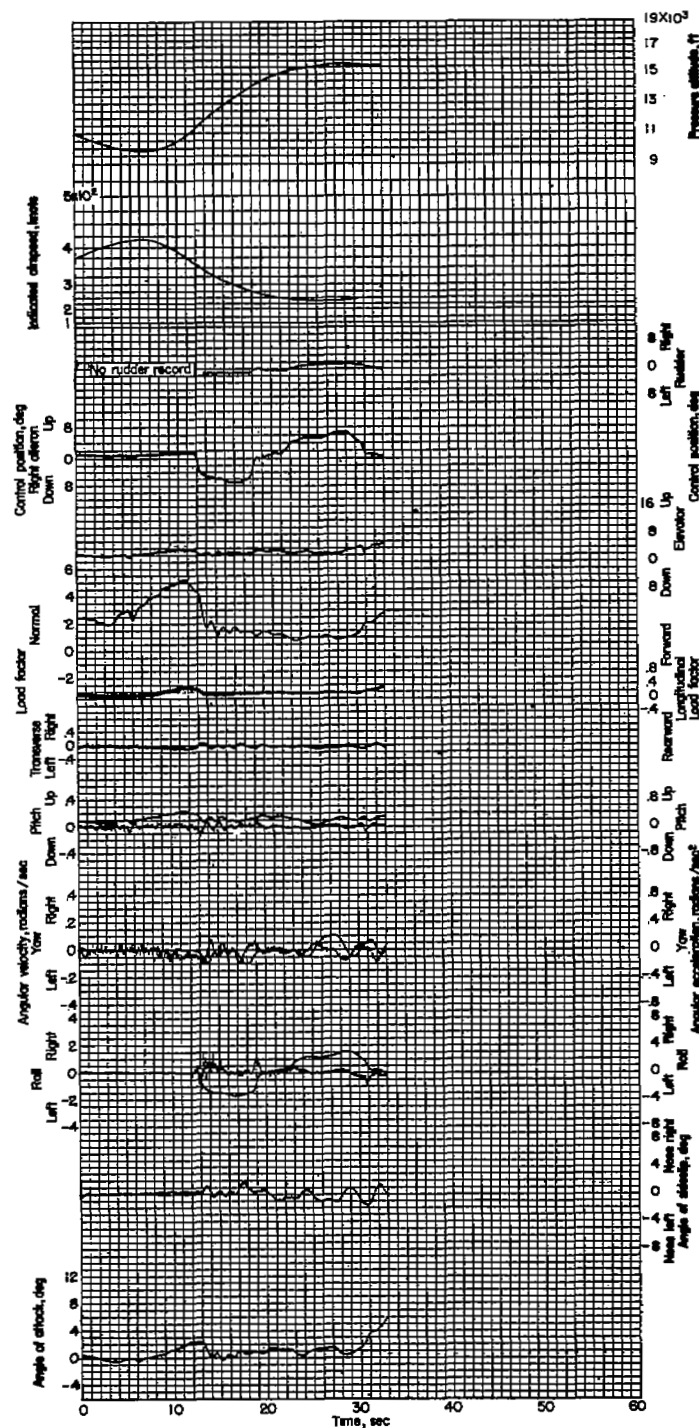


Figure 115.- Left and right one and one-half aileron rolls. Pilot F wearing anti-gravity suit; airplane weight, 11,805 pounds; center of gravity at 26.5 percent M.A.C.

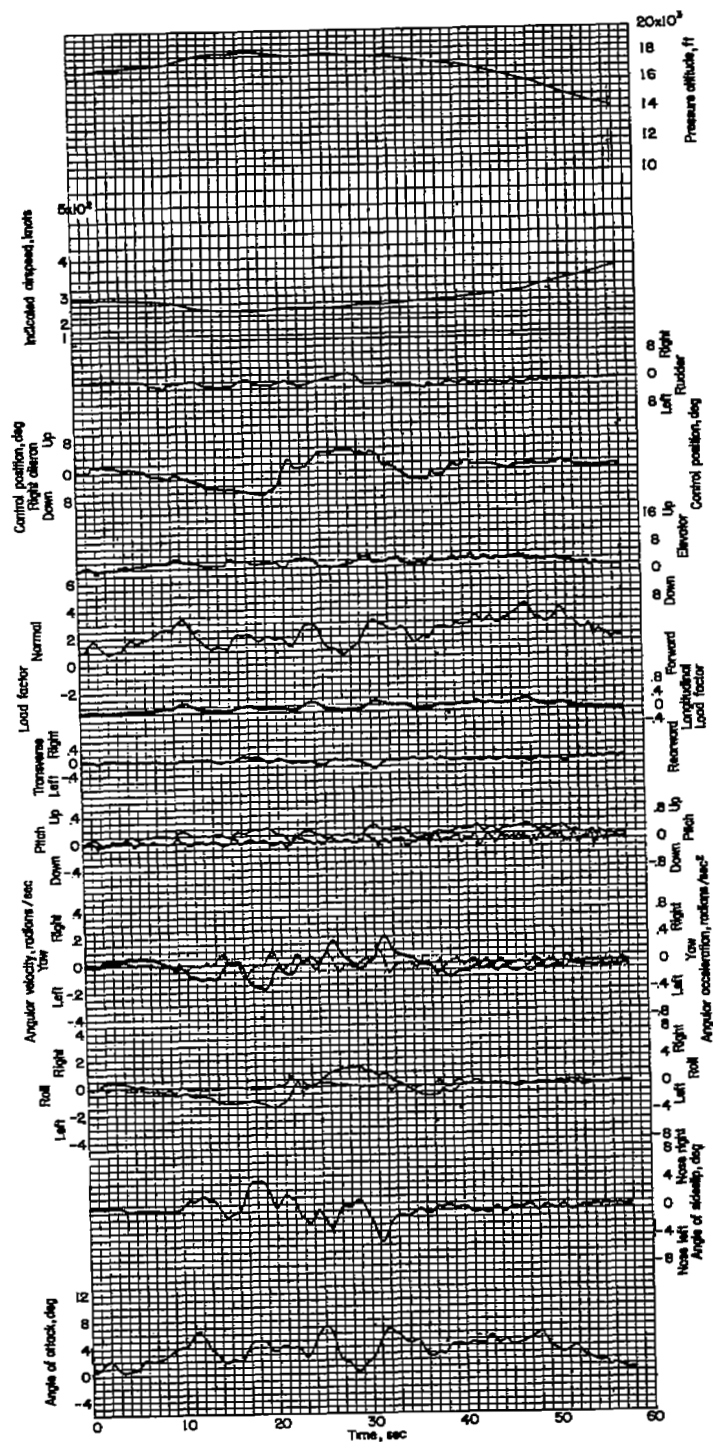


Figure 116.- Two consecutive left aileron rolls and one right aileron roll. Pilot C with radar observer; airplane weight, 12,600 pounds; center of gravity at 26.8 percent M.A.C.

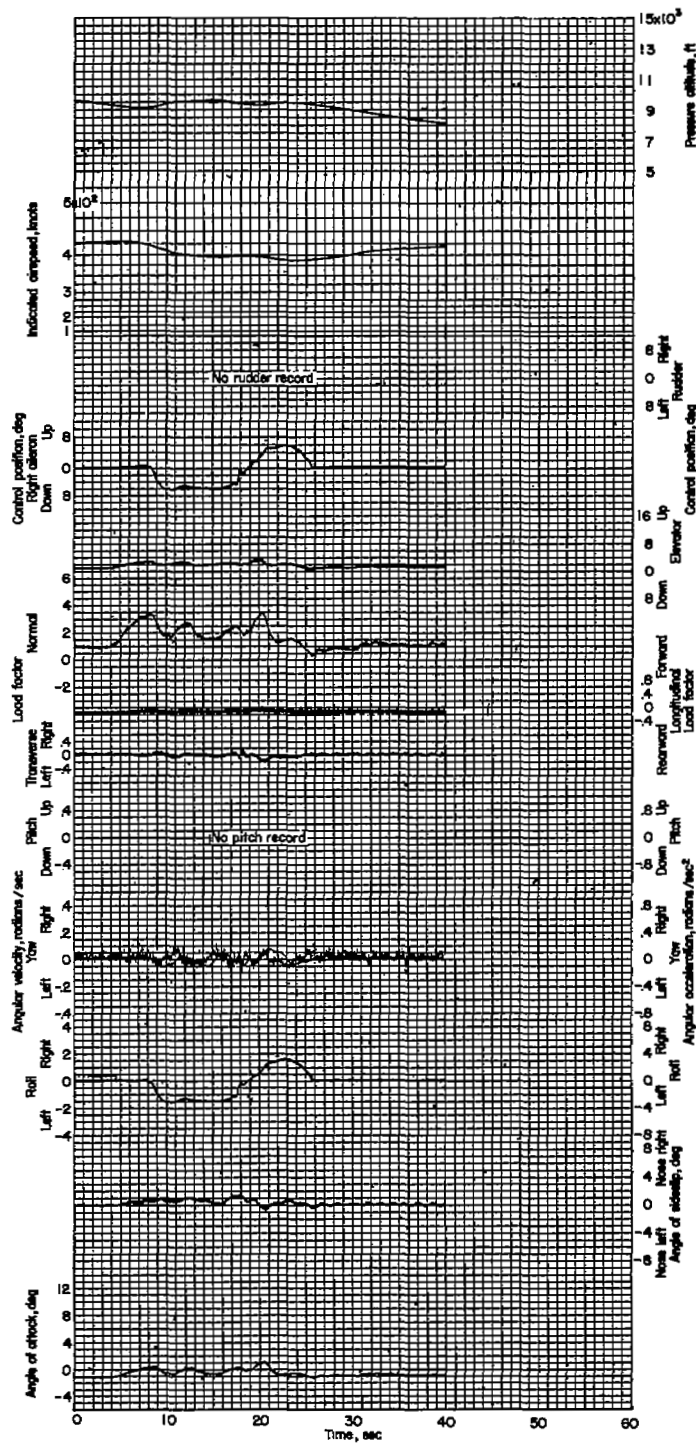


Figure 117.- Two consecutive left aileron rolls and one right aileron roll. Pilot G with radar observer; airplane weight, 12,600 pounds; center of gravity at 26.7 percent M.A.C.

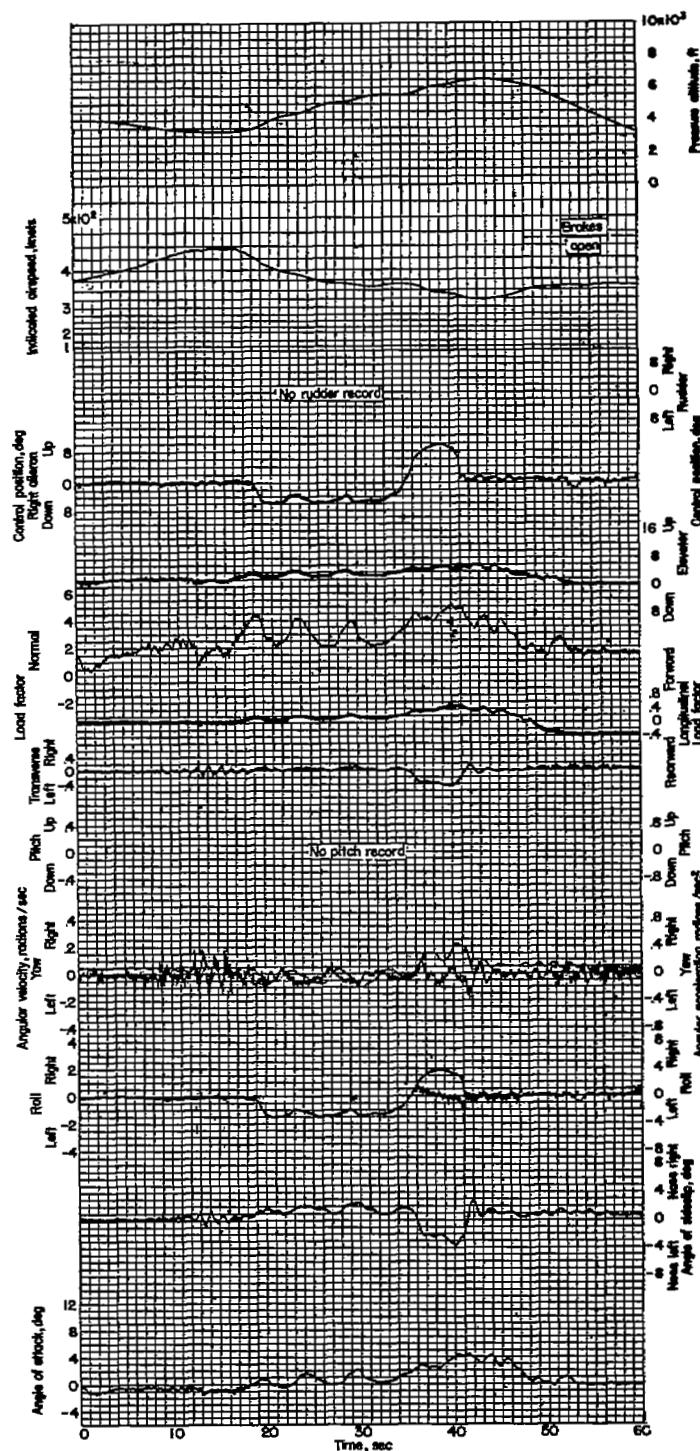


Figure 118.- Three consecutive left aileron rolls and one right aileron roll. Pilot G with radar observer; airplane weight, 12,145 pounds; center of gravity at 25.8 percent M.A.C.

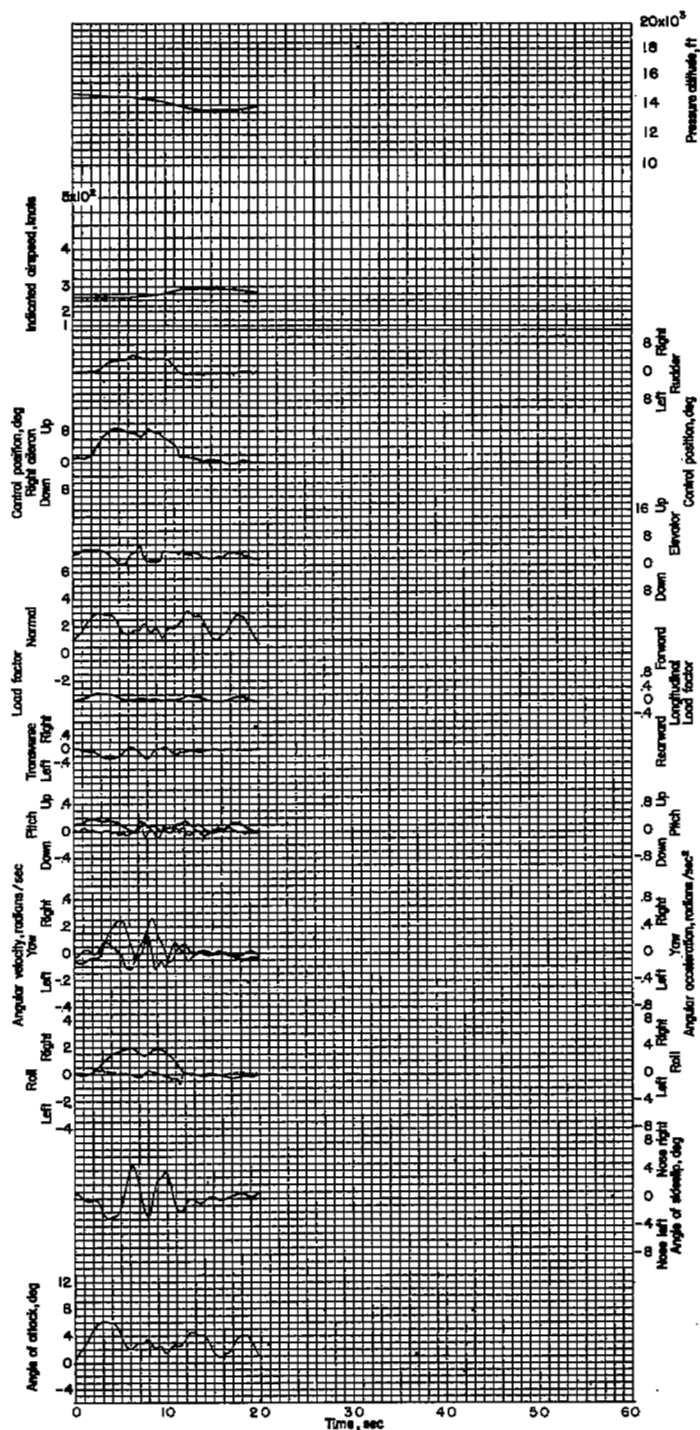


Figure 119.- Two consecutive right aileron rolls. Pilot A; airplane weight, 12,195 pounds; center of gravity at 27.3 percent M.A.C.

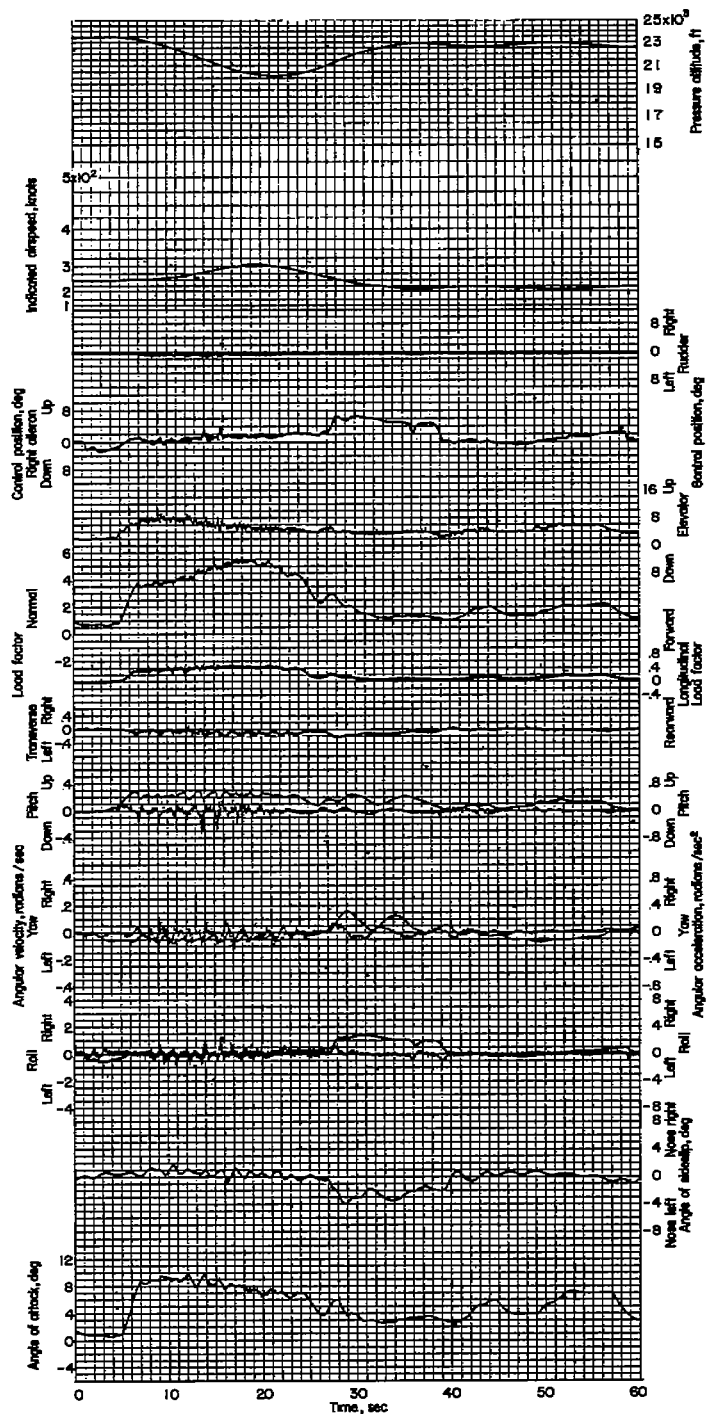


Figure 120.- Two consecutive right aileron rolls. Pilot B; airplane weight, 12,000 pounds; center of gravity at 26.9 percent M.A.C.

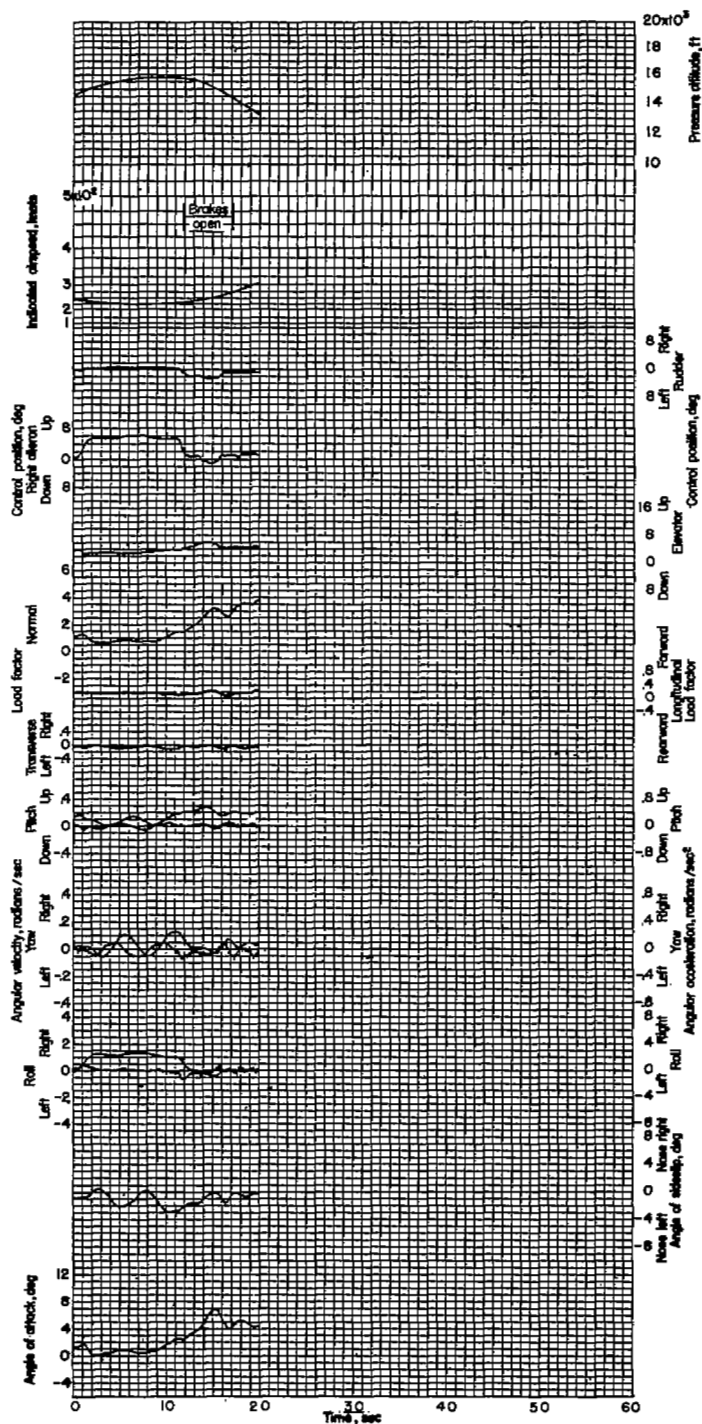


Figure 121.- Two consecutive right aileron rolls. Pilot F wearing anti-gravity suit; airplane weight, 11,740 pounds; center of gravity at 26.4 percent M.A.C.

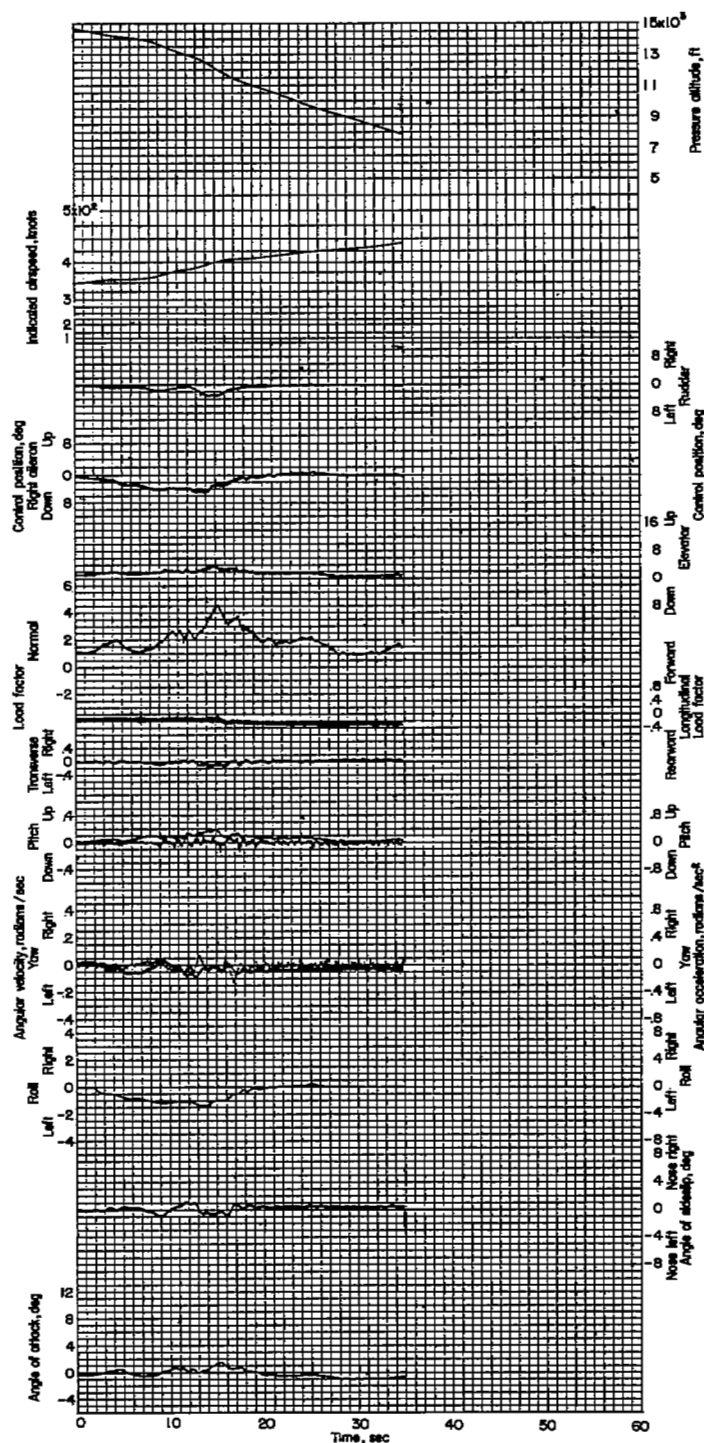


Figure 122.- Two consecutive left aileron rolls. Pilot C with radar observer; airplane weight, 12,010 pounds; center of gravity at 25.6 percent M.A.C.

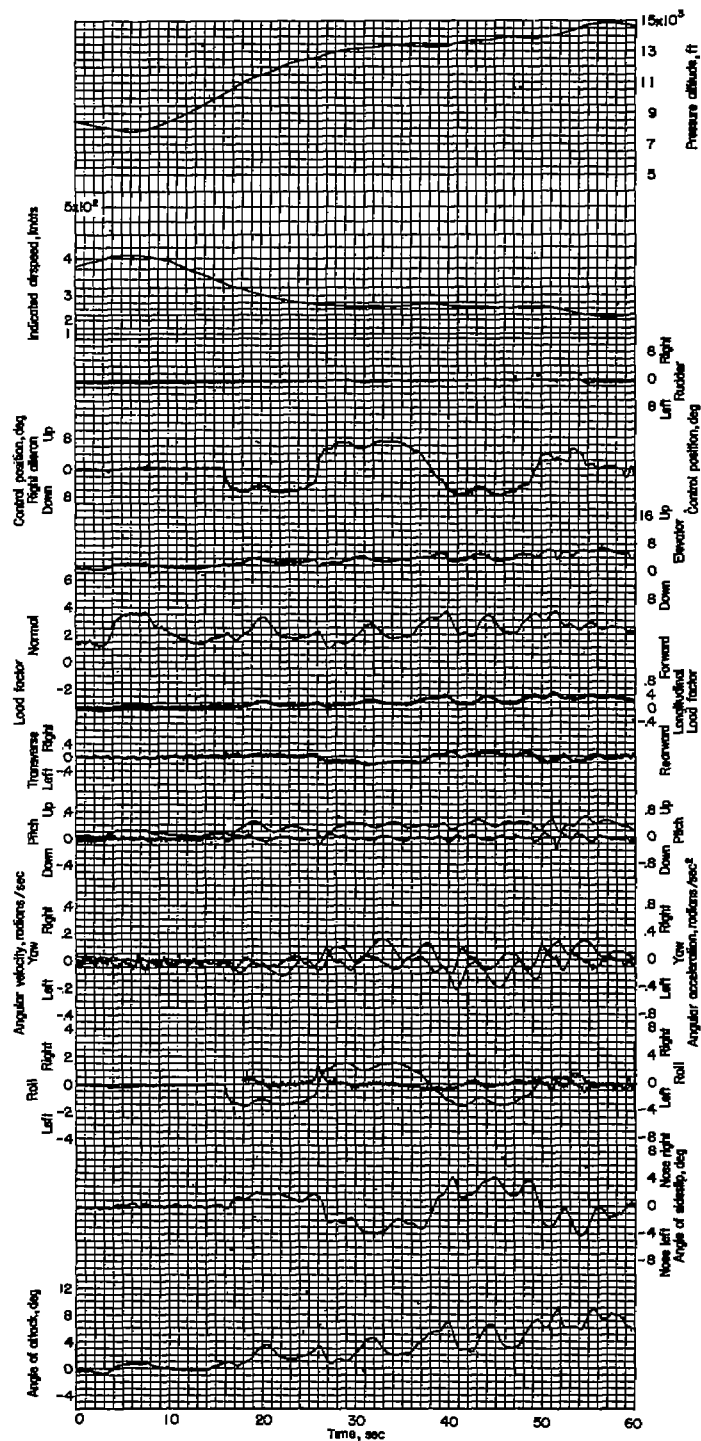


Figure 123.- Two consecutive left, right, and left aileron rolls. Pilot G; airplane weight, 11,920 pounds; center of gravity at 26.7 percent M.A.C.

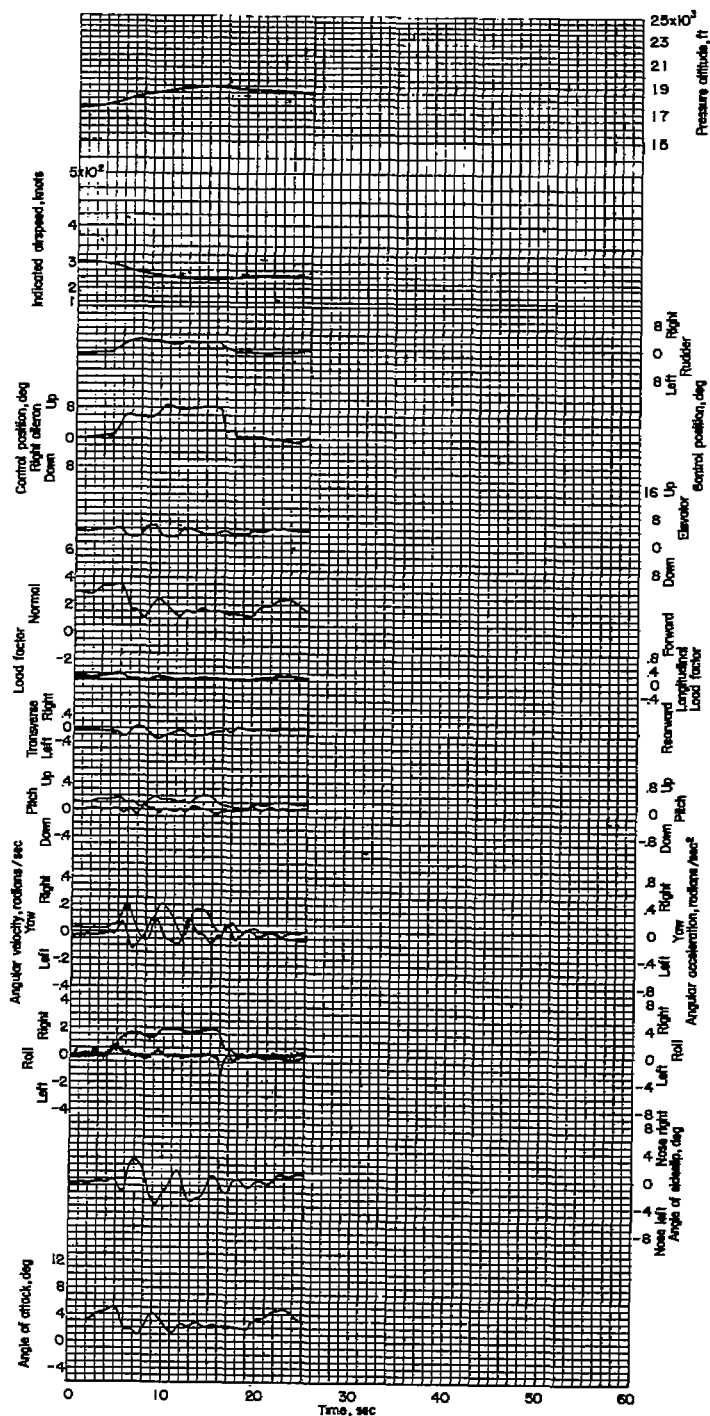


Figure 124.- Three consecutive right aileron rolls. Pilot A; airplane weight, 11,730 pounds; center of gravity at 26.4 percent M.A.C.

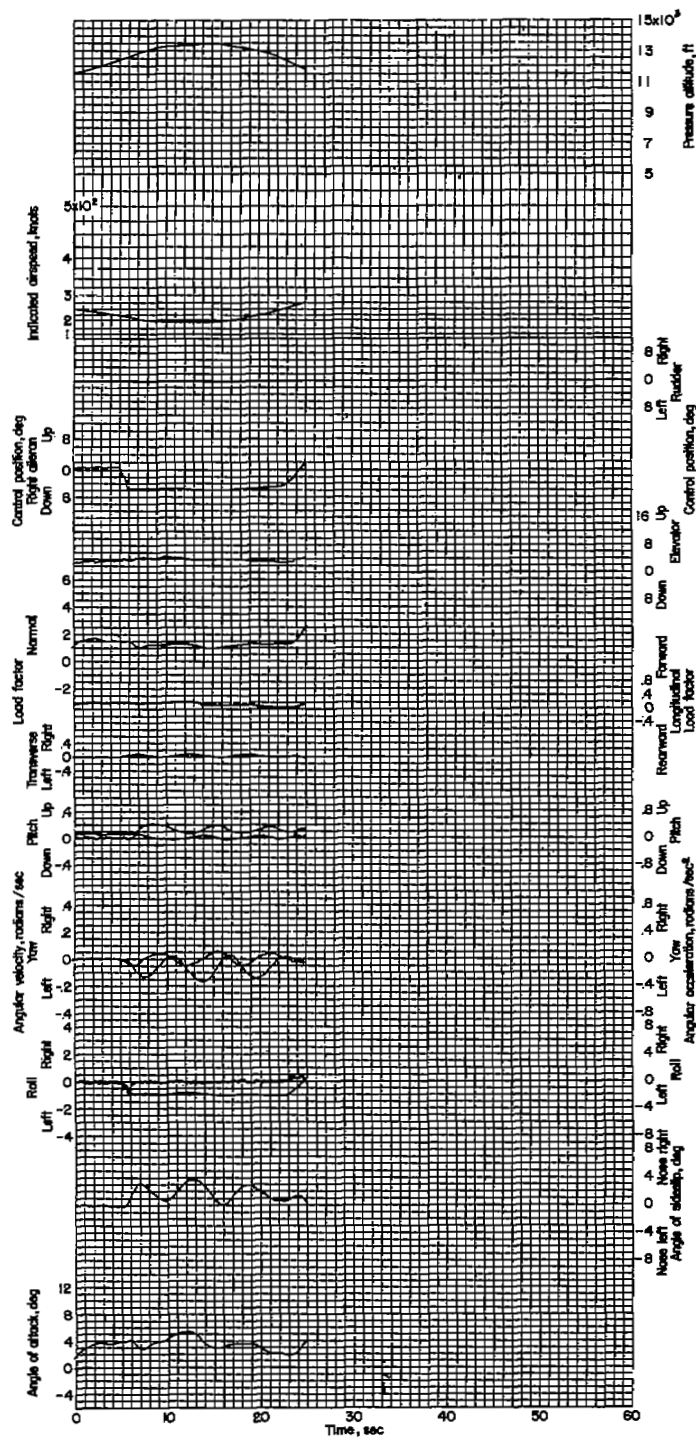


Figure 125.- Three consecutive left aileron rolls. Pilot B; airplane weight, 11,960 pounds; center of gravity at 26.8 percent M.A.C.

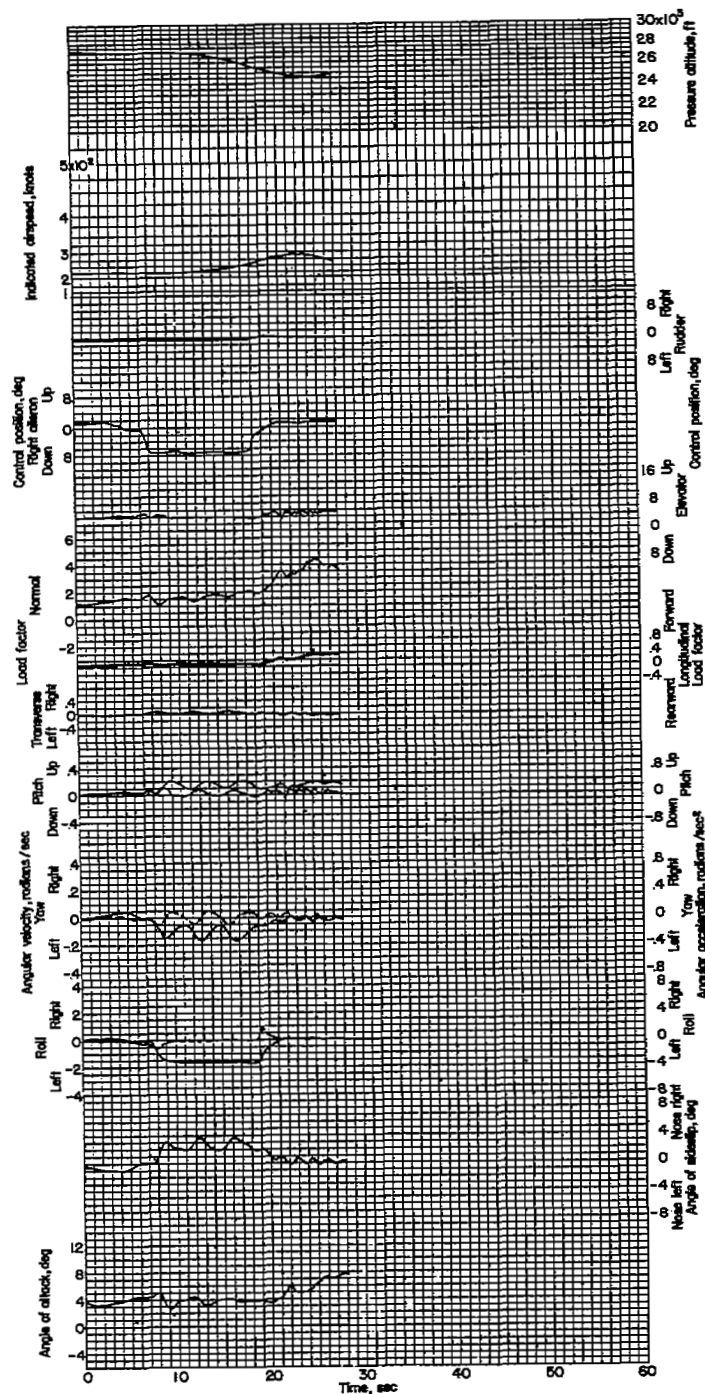


Figure 126.- Three consecutive left aileron rolls. Pilot B with radar observer; airplane weight, 12,170 pounds; center of gravity at 25.9 percent M.A.C.

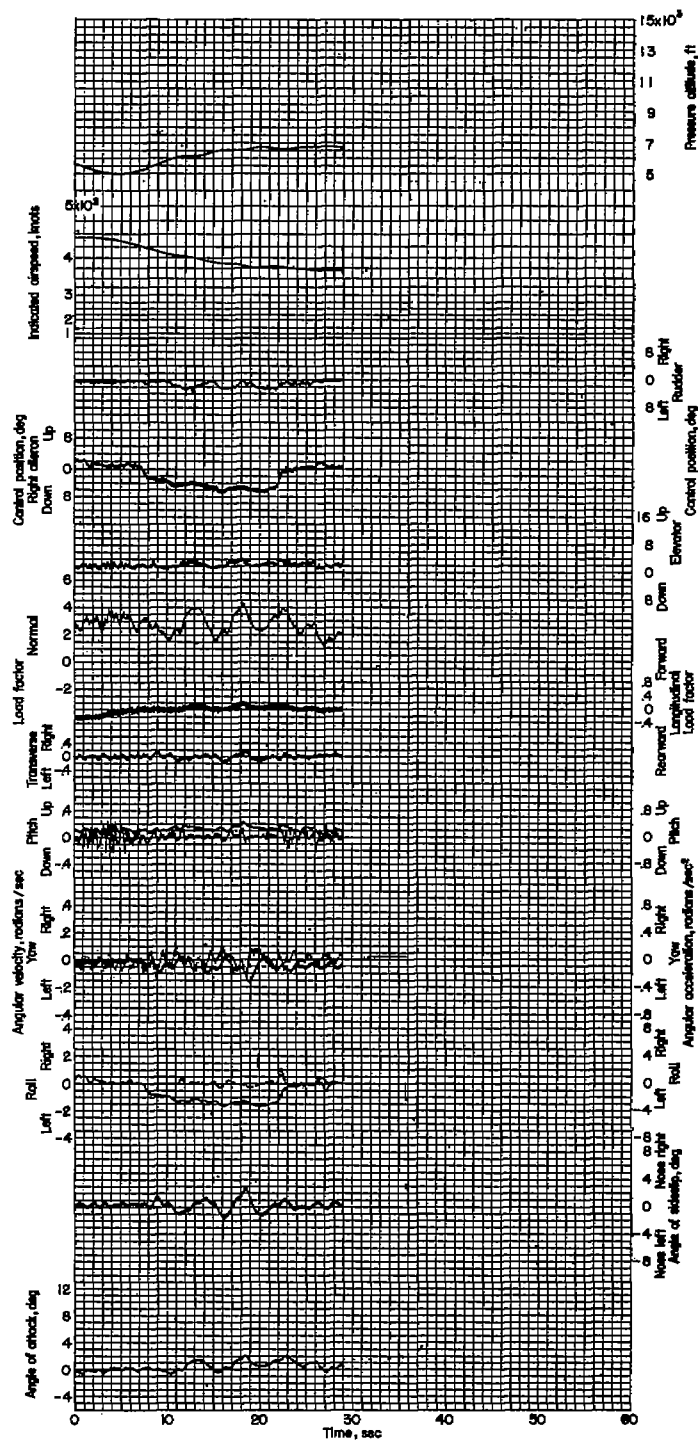


Figure 127.- Three consecutive left aileron rolls. Pilot C with radar observer; airplane weight, 12,425 pounds; center of gravity at 26.4 percent M.A.C.

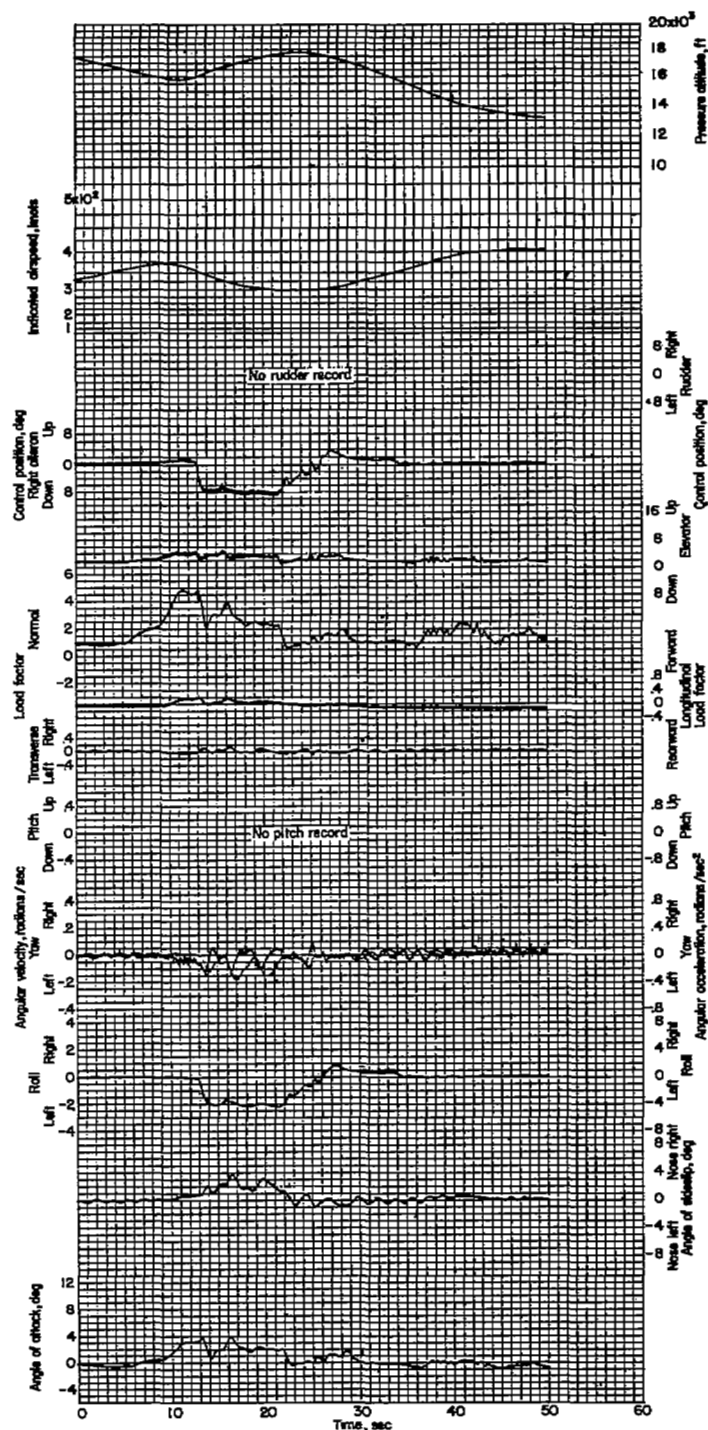


Figure 128.- Three consecutive left aileron rolls. Pilot G with radar observer; airplane weight, 12,830 pounds; center of gravity at 26.9 percent M.A.C.

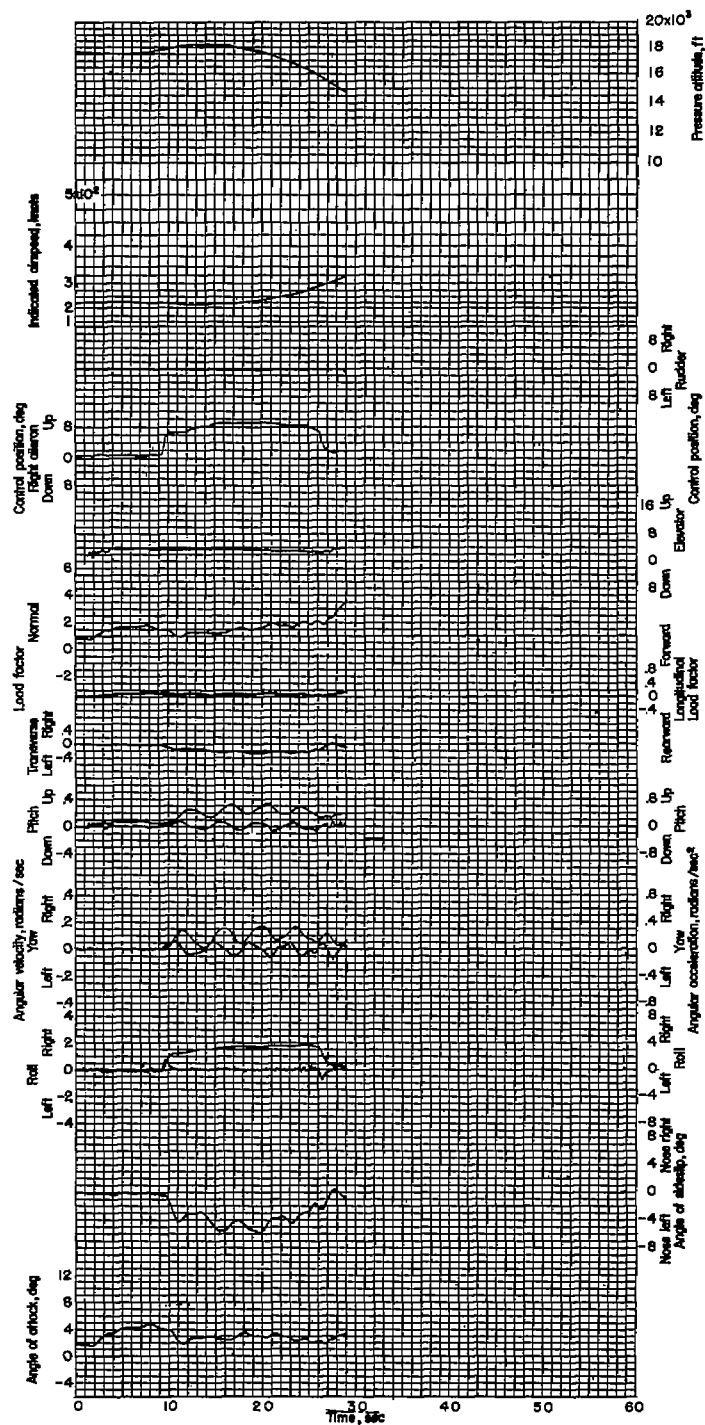


Figure 129.- Four consecutive right aileron rolls. Pilot B; airplane weight, 12,075 pounds; center of gravity at 27.0 percent M.A.C.

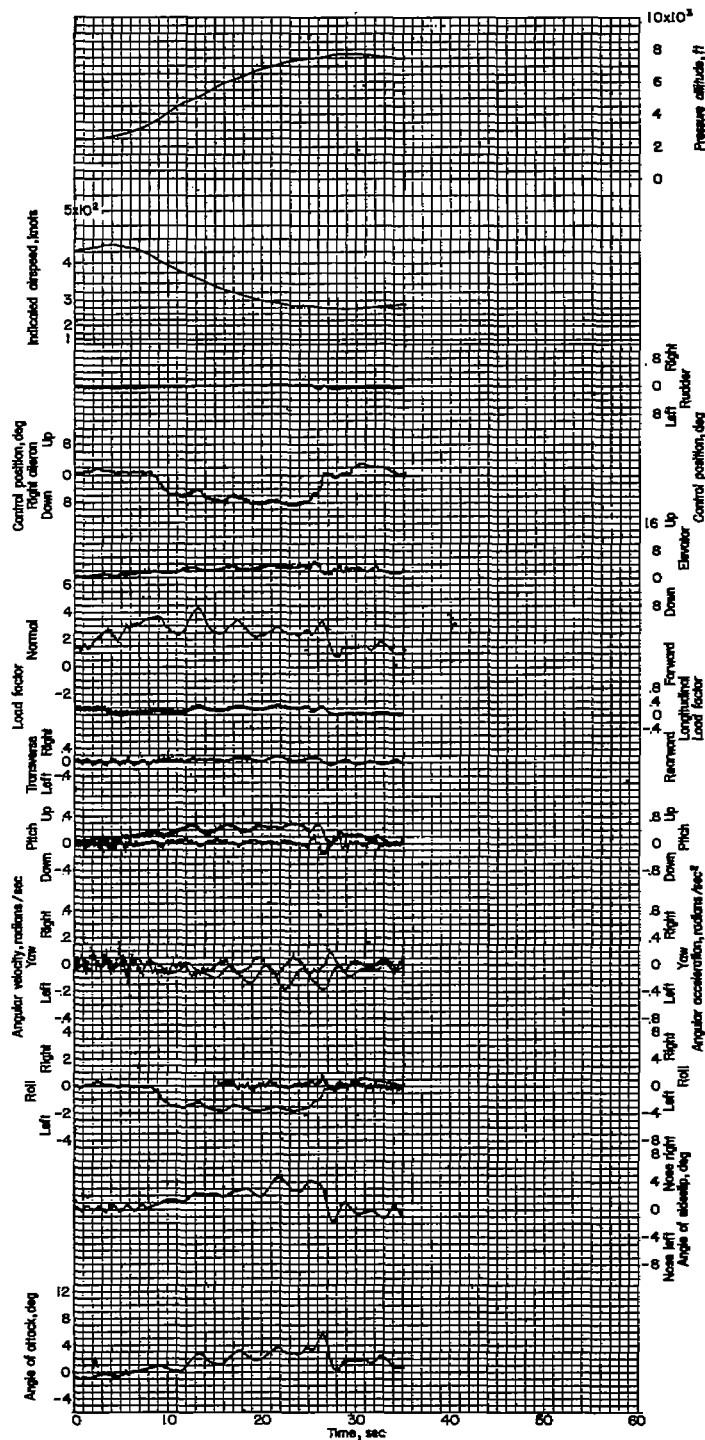


Figure 130.- Four consecutive left aileron rolls. Pilot G; airplane weight, 12,640 pounds; center of gravity at 27.7 percent M.A.C.

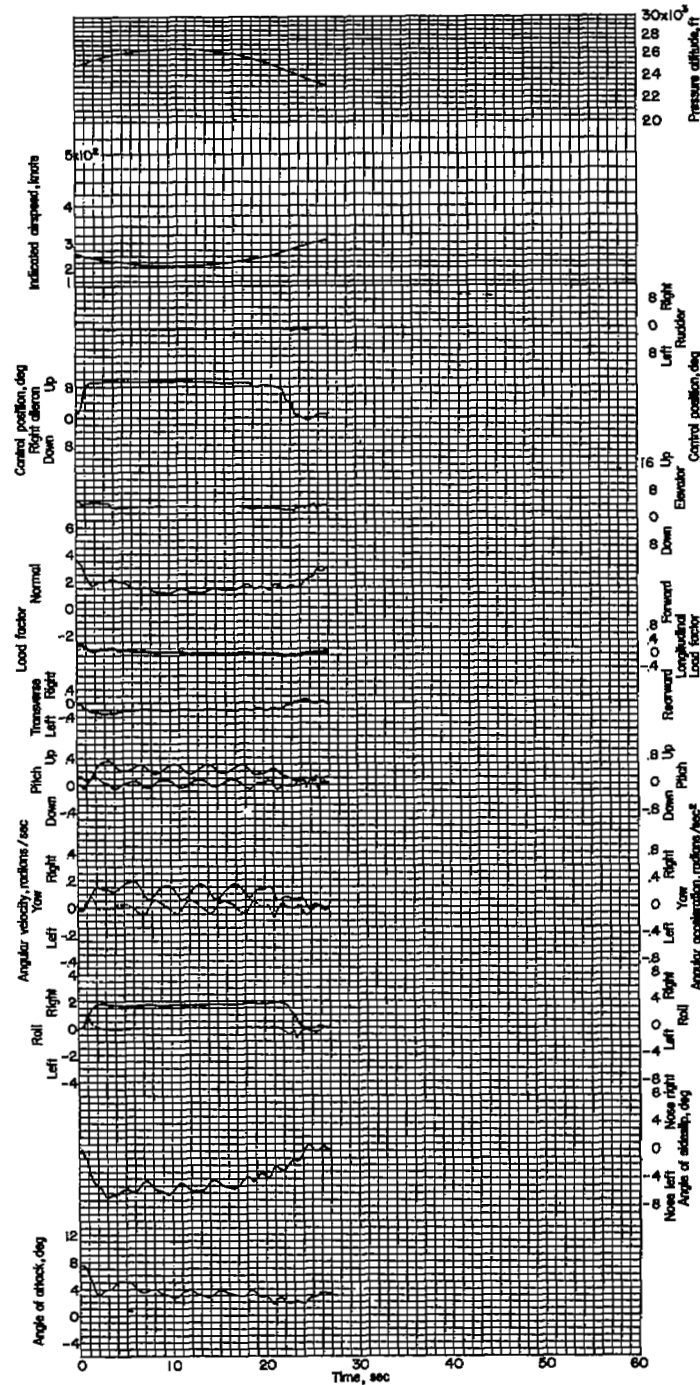


Figure 131.- Six consecutive right aileron rolls. Pilot B with radar observer; airplane weight, 12,155 pounds; center of gravity at 25.9 percent M.A.C.



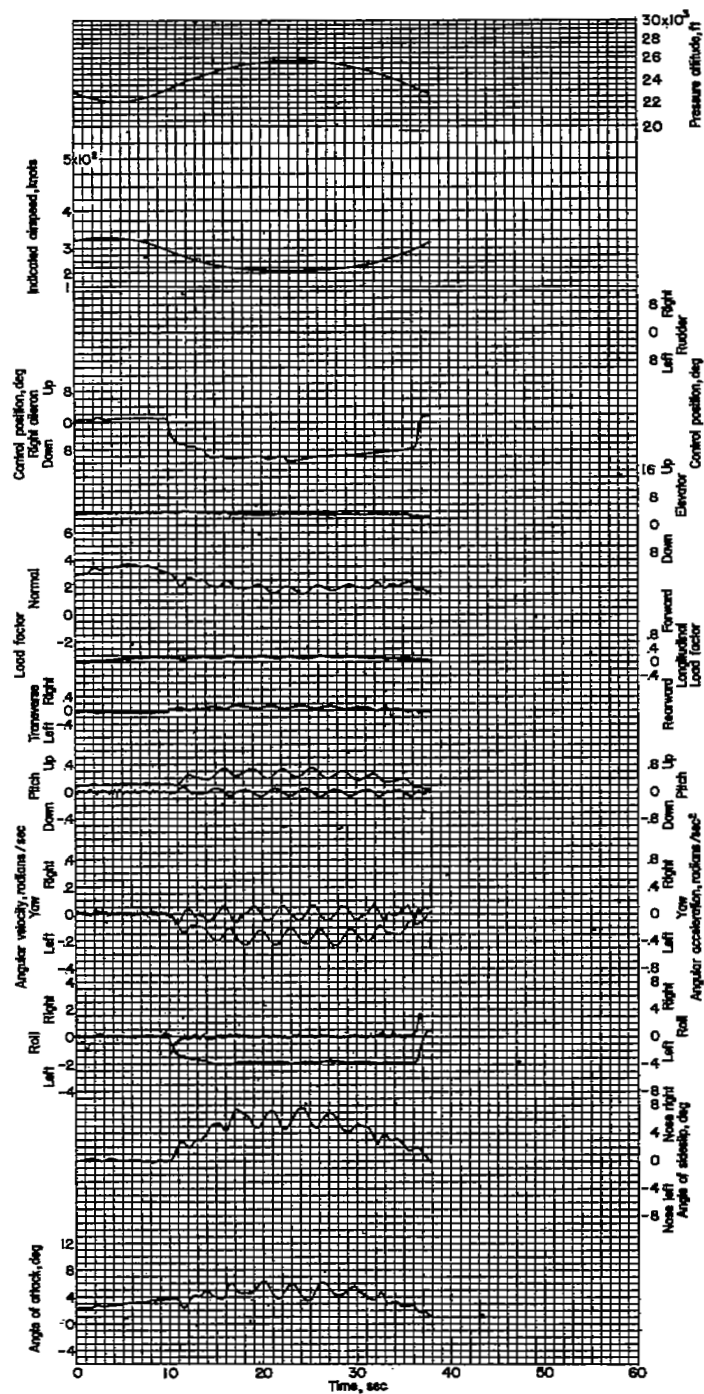


Figure 132.- Eight consecutive left aileron rolls. Pilot B; airplane weight, 12,080 pounds; center of gravity at 27.0 percent M.A.C.

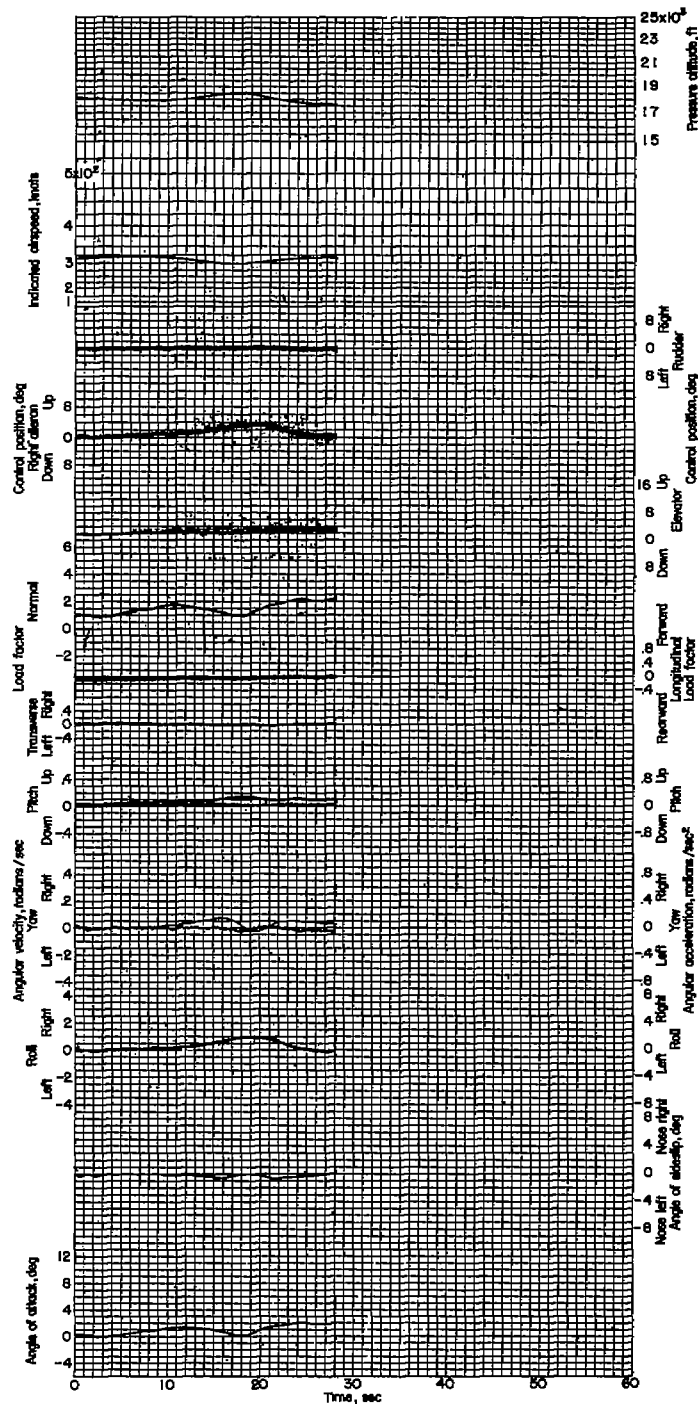
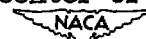


Figure 133.- Right barrel roll. Pilot F wearing anti-gravity suit and with radar observer; airplane weight, 12,475 pounds; center of gravity at 26.5 percent M.A.C.



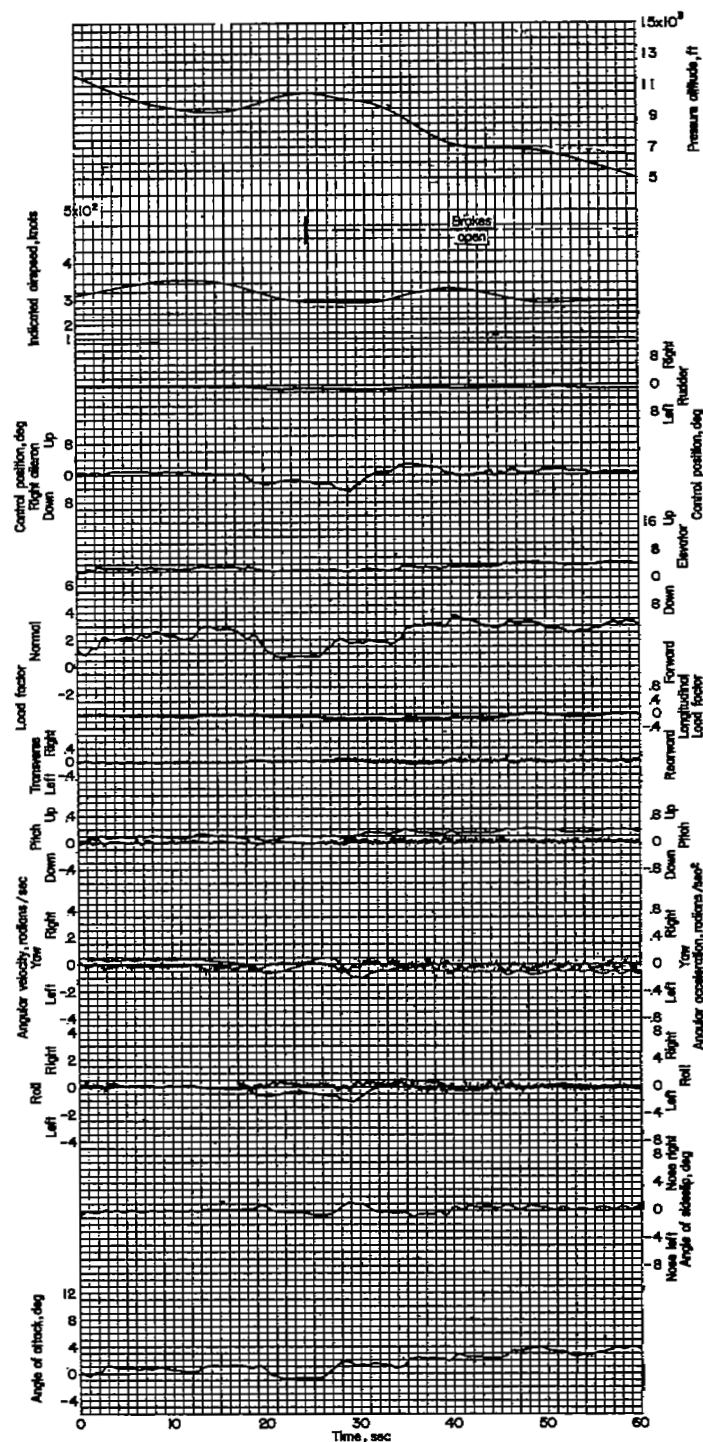


Figure 134.- Left barrel roll. Pilot F wearing anti-gravity suit; airplane weight, 11,600 pounds; center of gravity at 26.1 percent M.A.C.

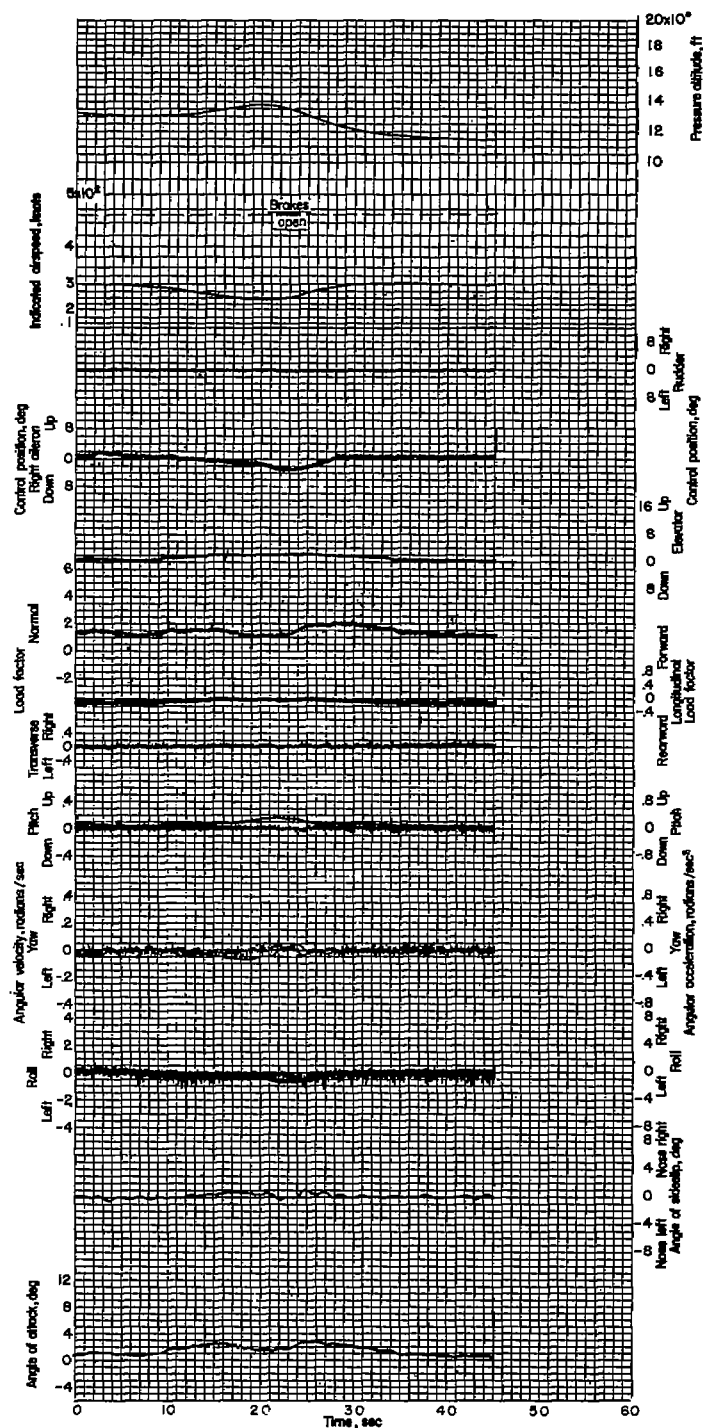


Figure 135.- Left barrel roll. Pilot F wearing anti-gravity suit and with radar observer; airplane weight, 12,315 pounds; center of gravity at 26.2 percent M.A.C.



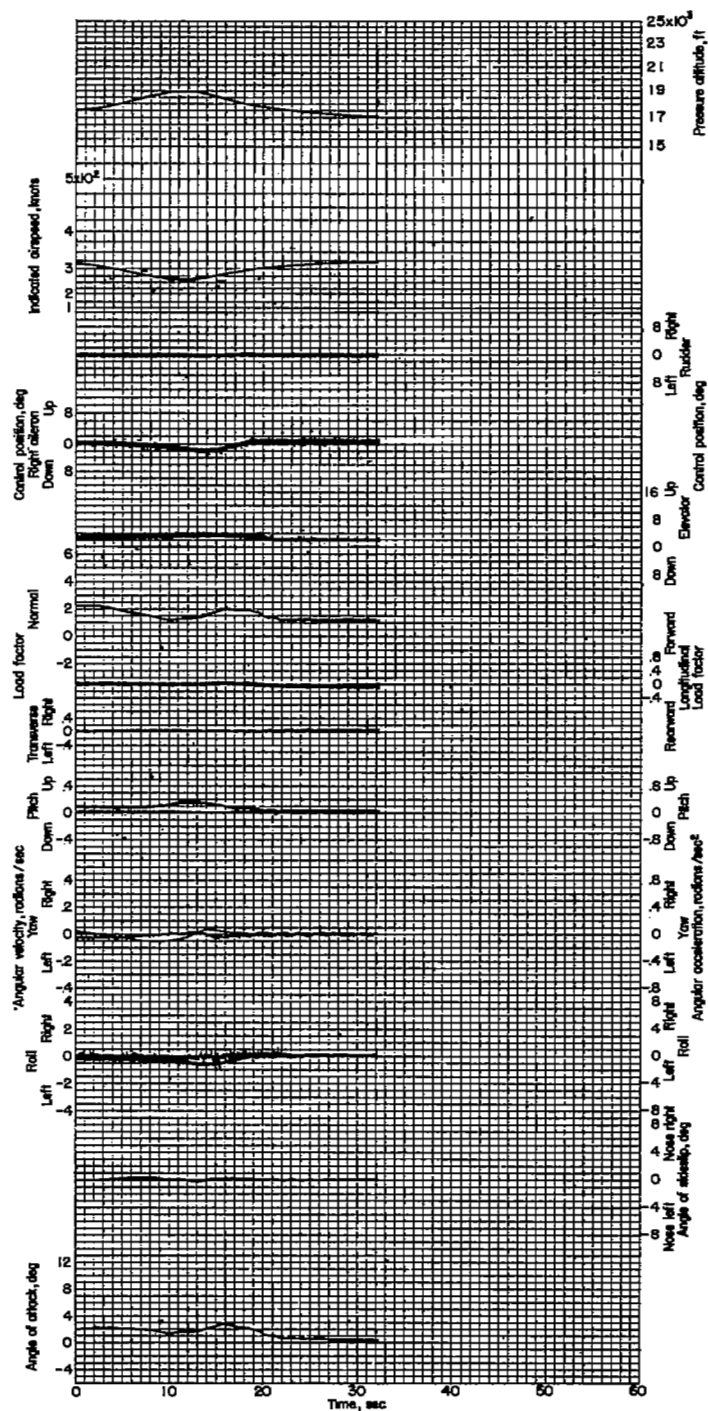


Figure 136.- Left barrel roll. Pilot F wearing anti-gravity suit and with radar observer; airplane weight, 12,455 pounds; center of gravity at 26.5 percent M.A.C.

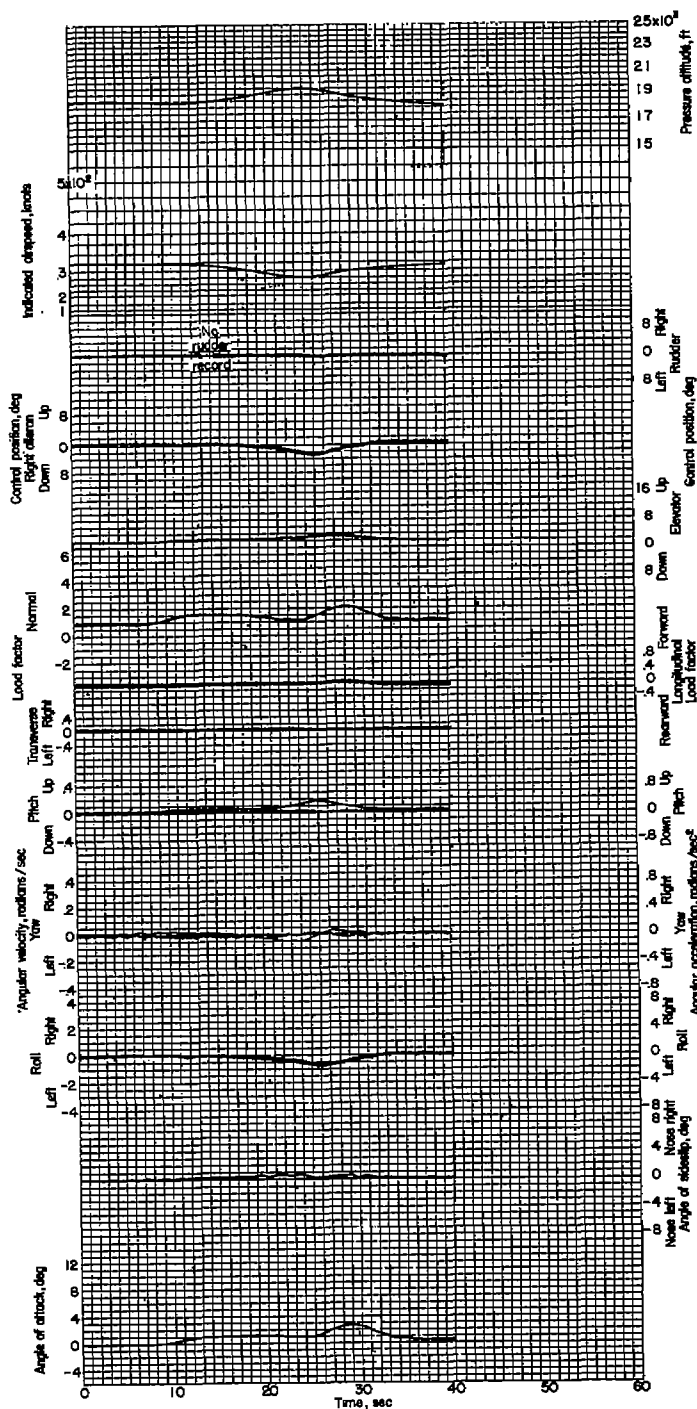


Figure 137.- Left barrel roll. Pilot F wearing anti-gravity suit and with radar observer; airplane weight, 12,490 pounds; center of gravity at 26.6 percent M.A.C.

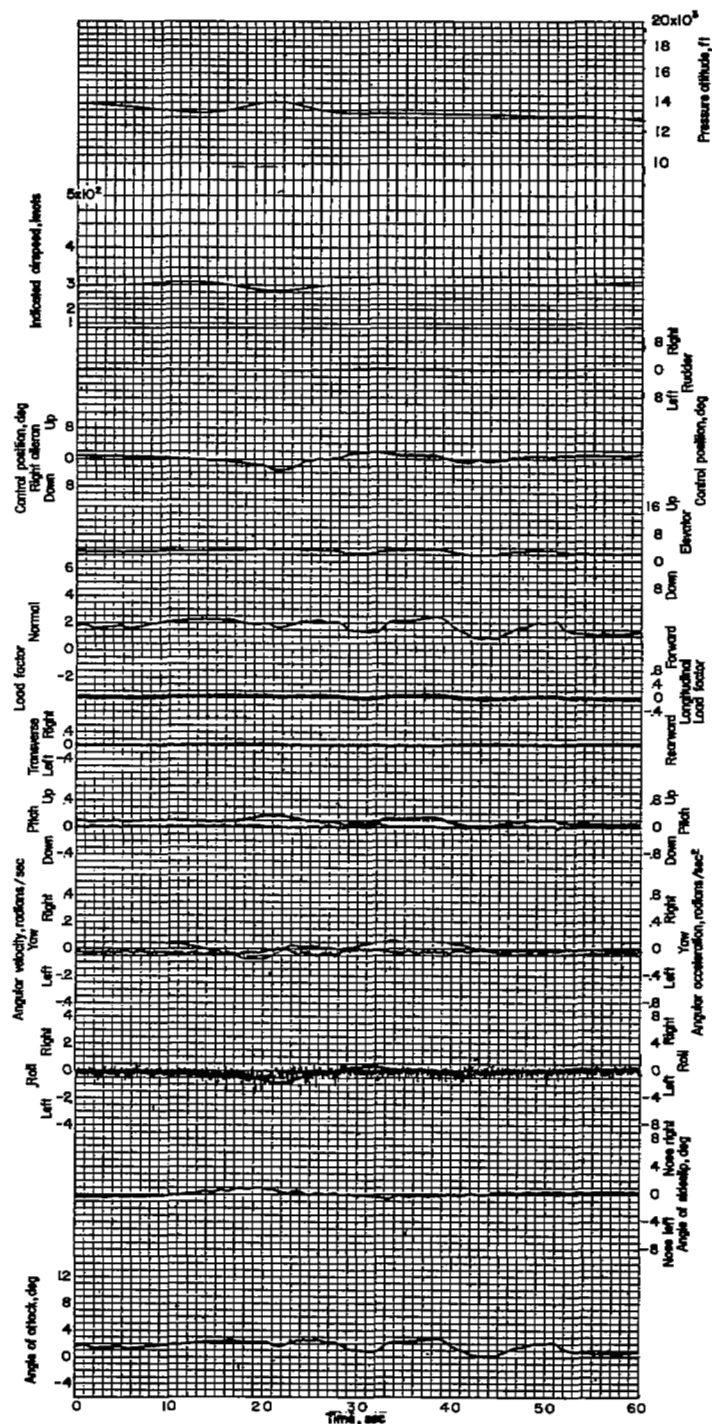


Figure 138.- Left barrel roll. Pilot F wearing anti-gravity suit and with radar observer; airplane weight, 12,250 pounds; center of gravity at 26.1 percent M.A.C.

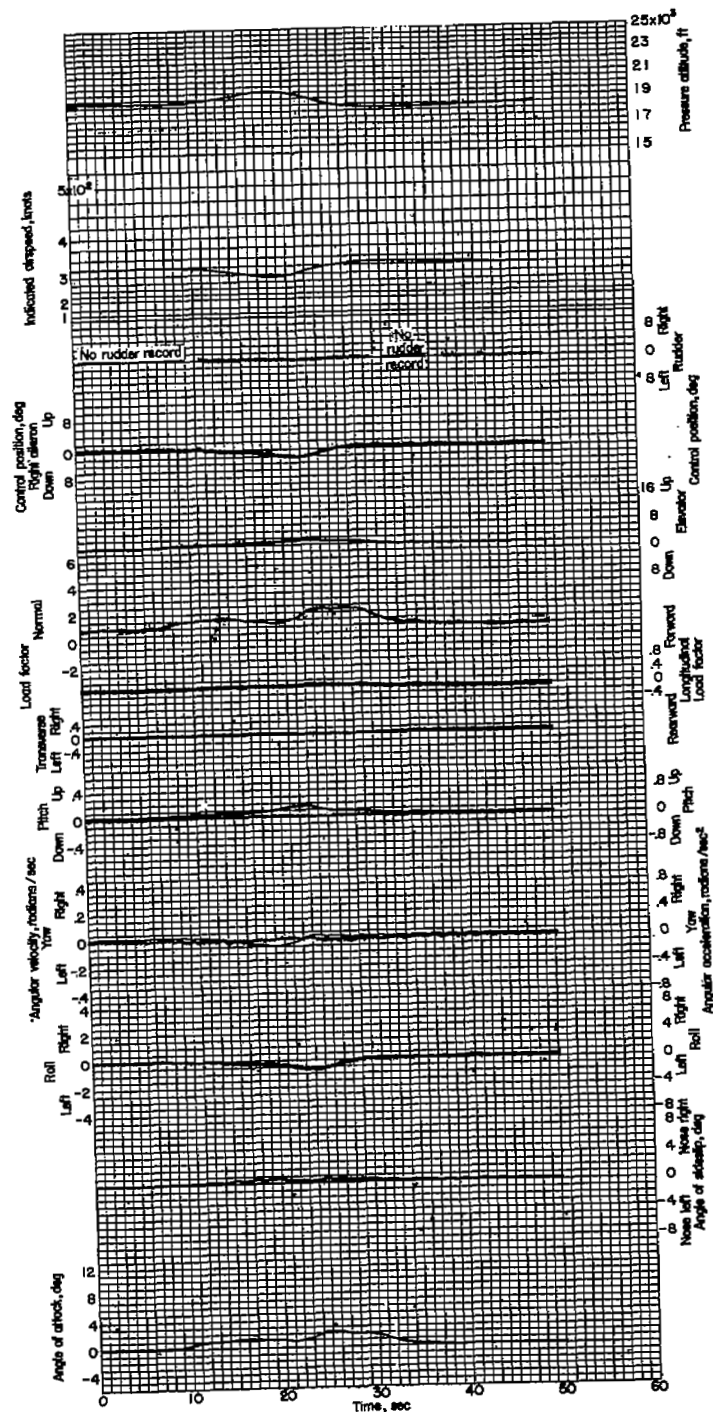


Figure 139.- Left barrel roll. Pilot F wearing anti-gravity suit and with radar observer; airplane weight, 12,510 pounds; center of gravity at 26.6 percent M.A.C.

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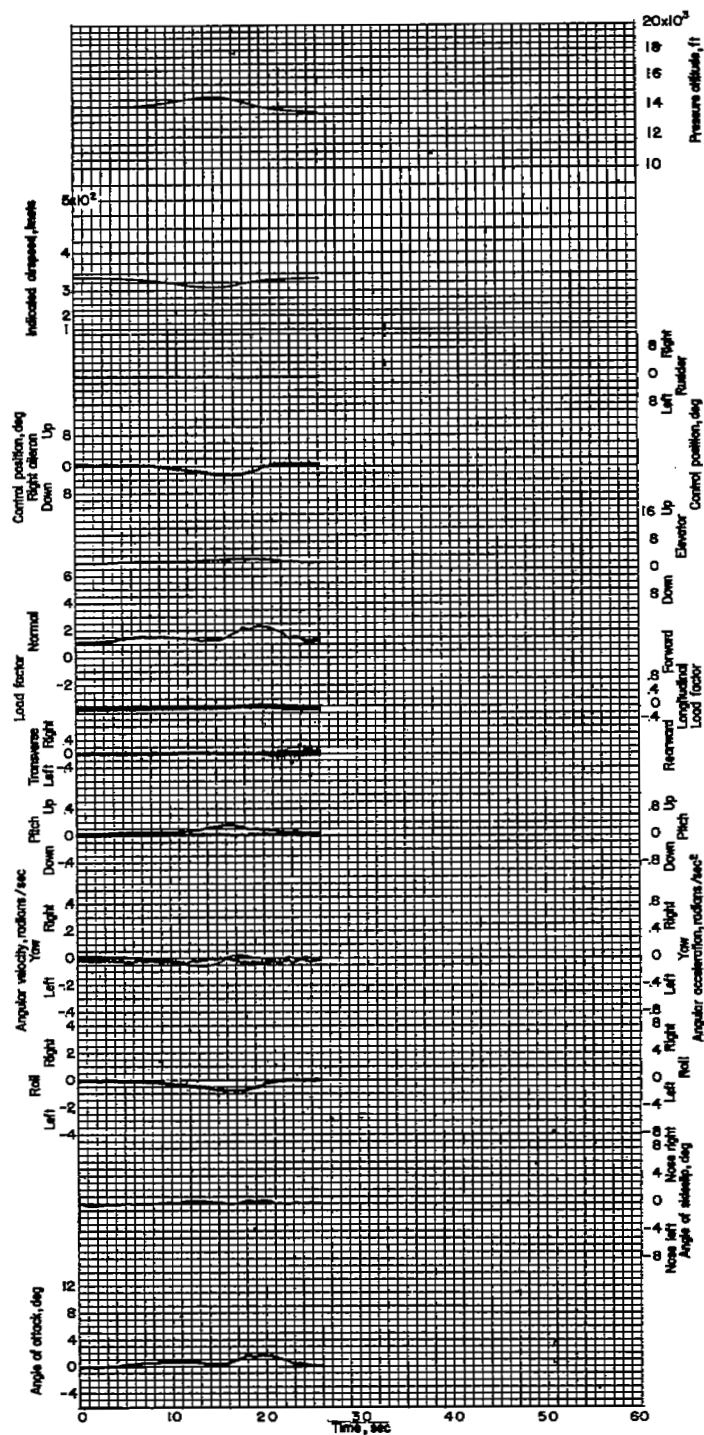


Figure 140.- Left barrel roll. Pilot F wearing anti-gravity suit and with radar observer; airplane weight, 12,340 pounds; center of gravity at 26.3 percent M.A.C.

NACA

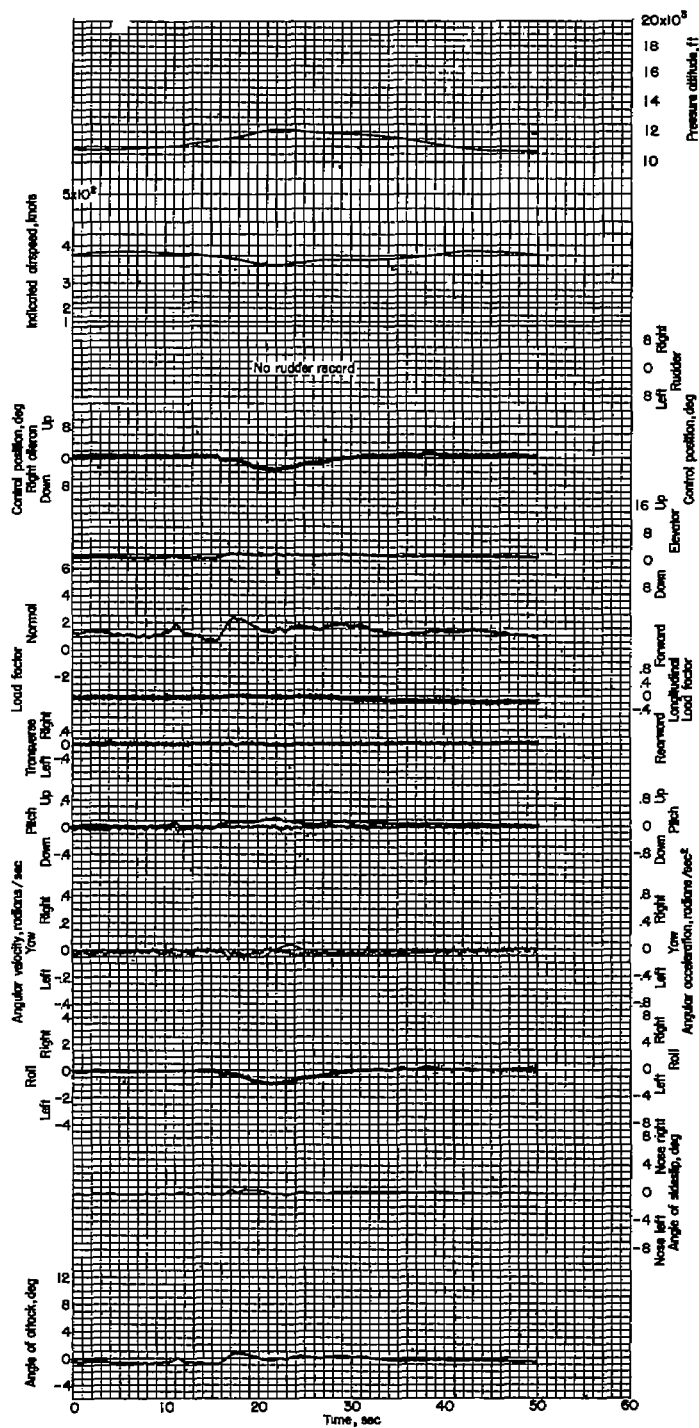


Figure 141.- Left barrel roll. Pilot F wearing anti-gravity suit and with radar observer; airplane weight, 12,180 pounds; center of gravity at 25.9 percent M.A.C.

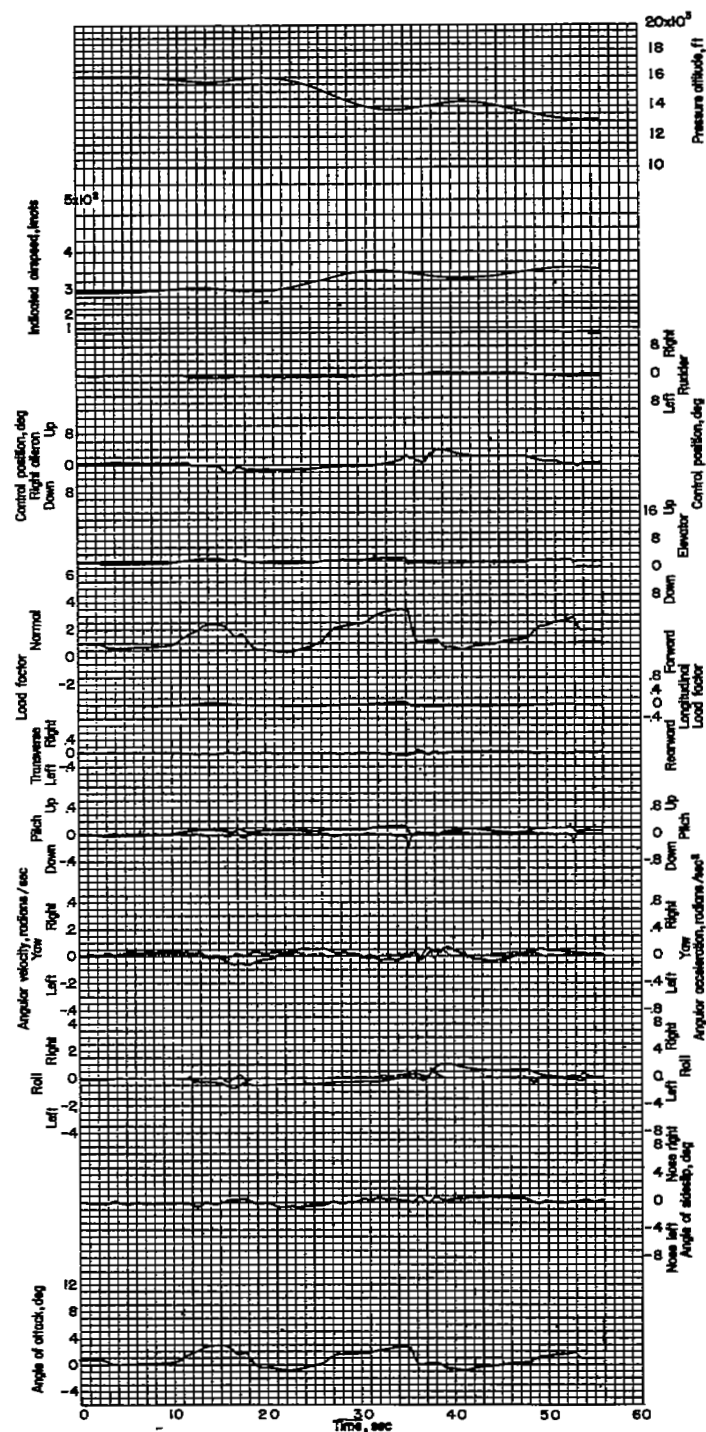


Figure 142.- Left and right barrel roll. Pilot A; airplane weight, 12,550 pounds; center of gravity at 27.8 percent M.A.C.

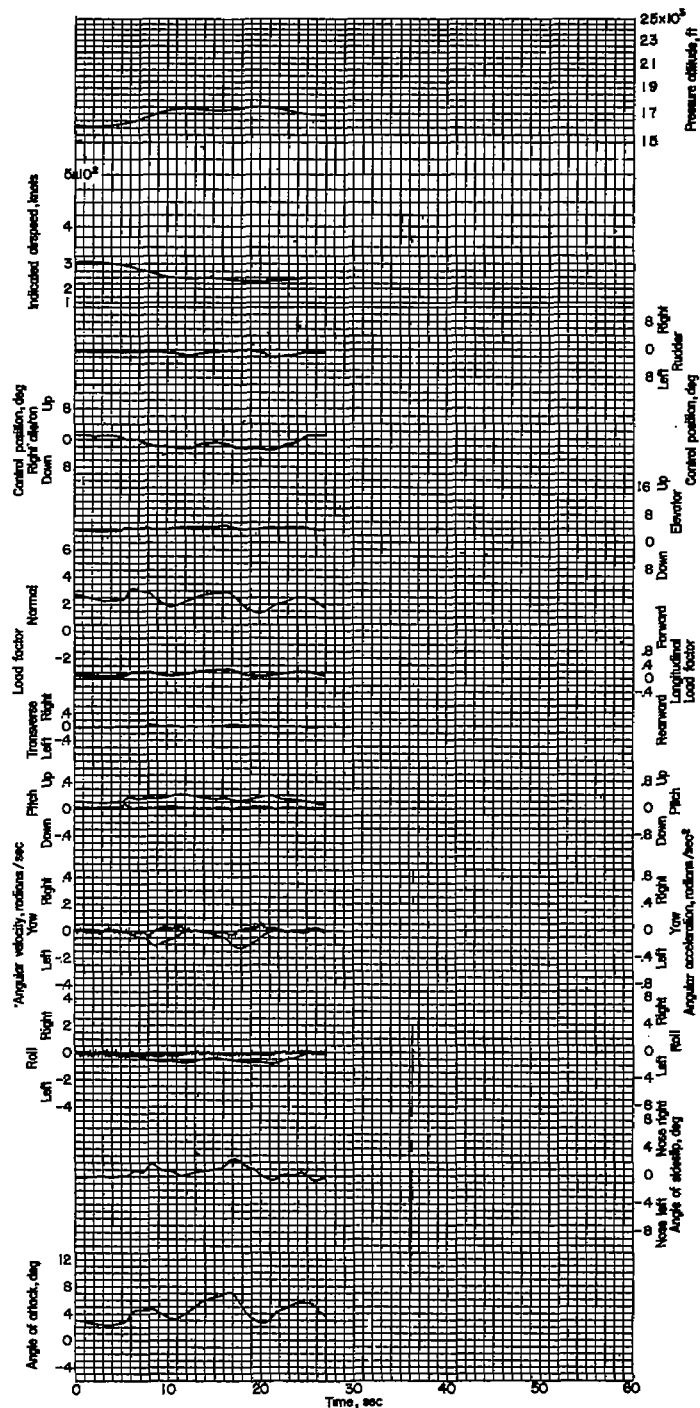


Figure 143.- Two consecutive left barrel rolls. Pilot E wearing anti-gravity suit; airplane weight, 11,840 pounds; center of gravity at 26.6 percent M.A.C.

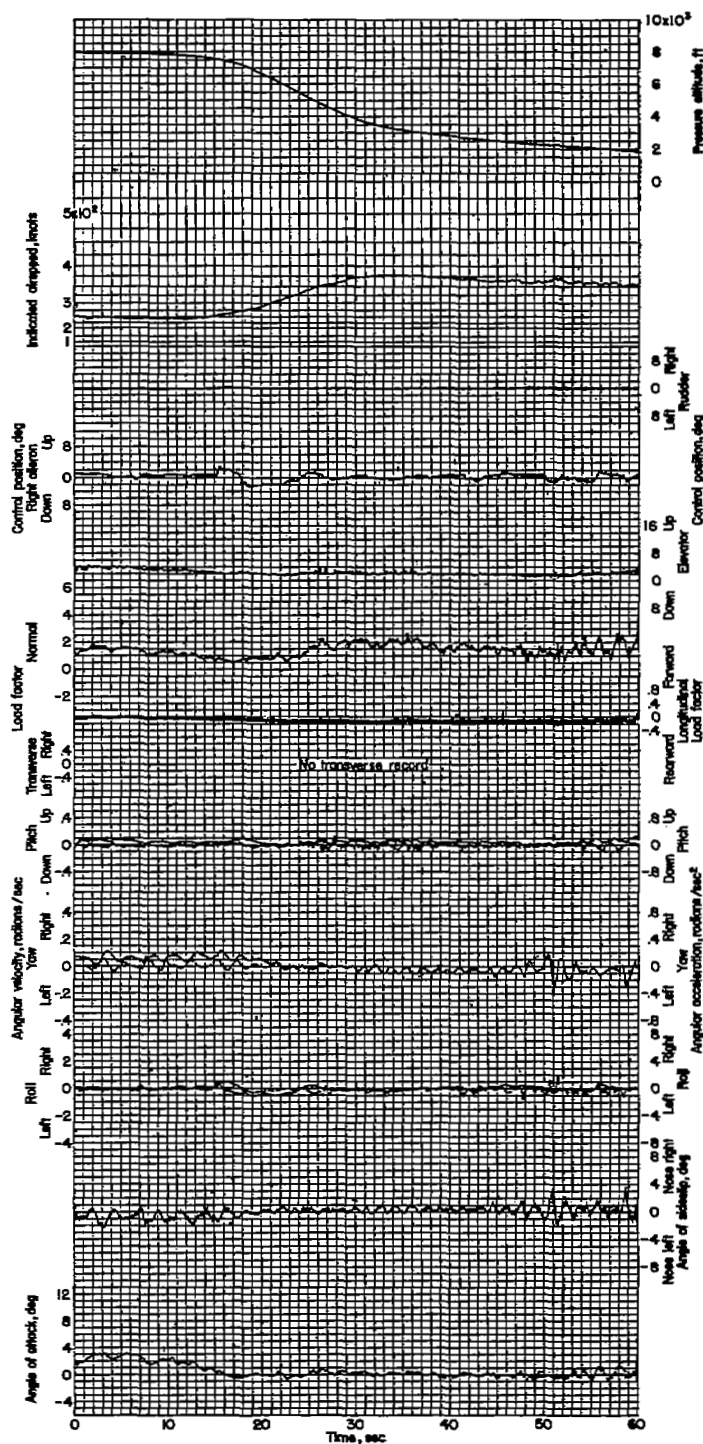


Figure 144.- Right roll entry into a dive. Pilot B with radar observer; airplane weight, 11,920 pounds; center of gravity at 25.4 percent M.A.C.

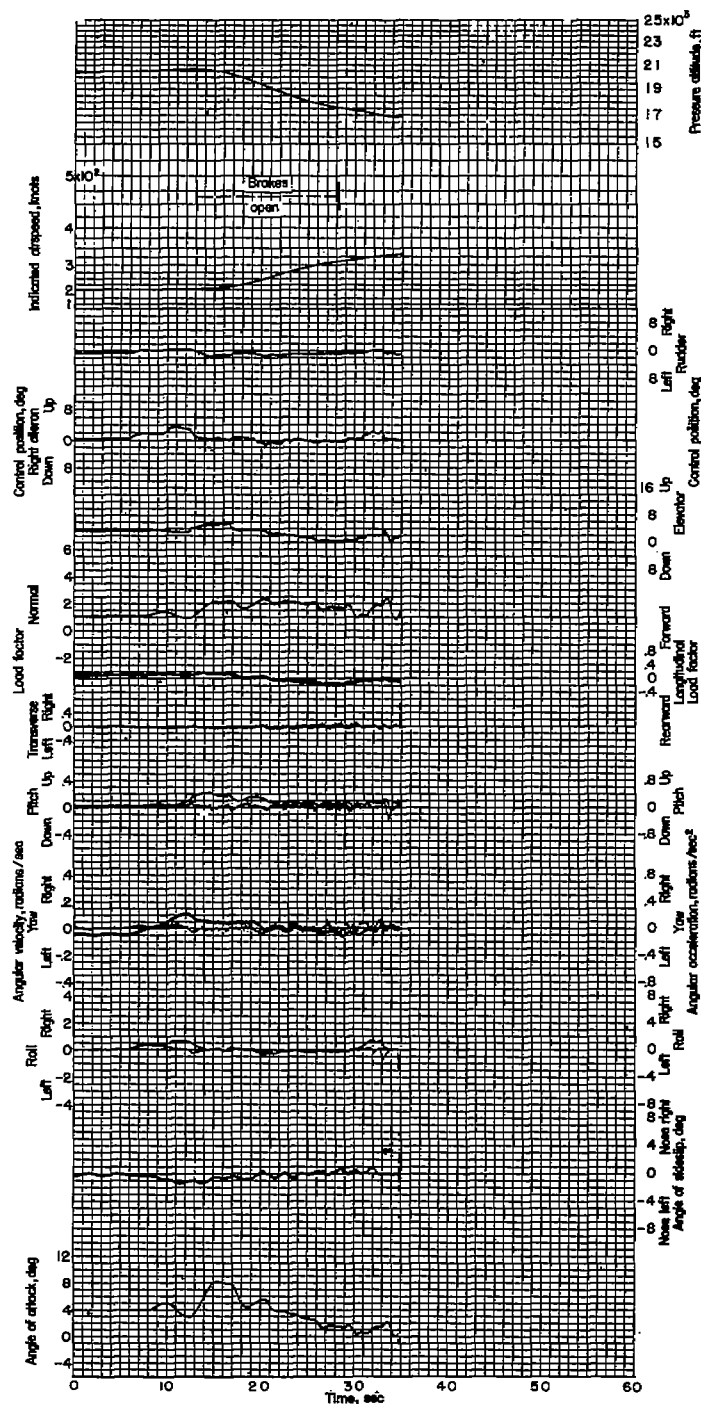


Figure 145.- Right roll entry into a dive. Pilot C with radar observer; airplane weight, 12,650 pounds; center of gravity at 26.9 percent M.A.C.

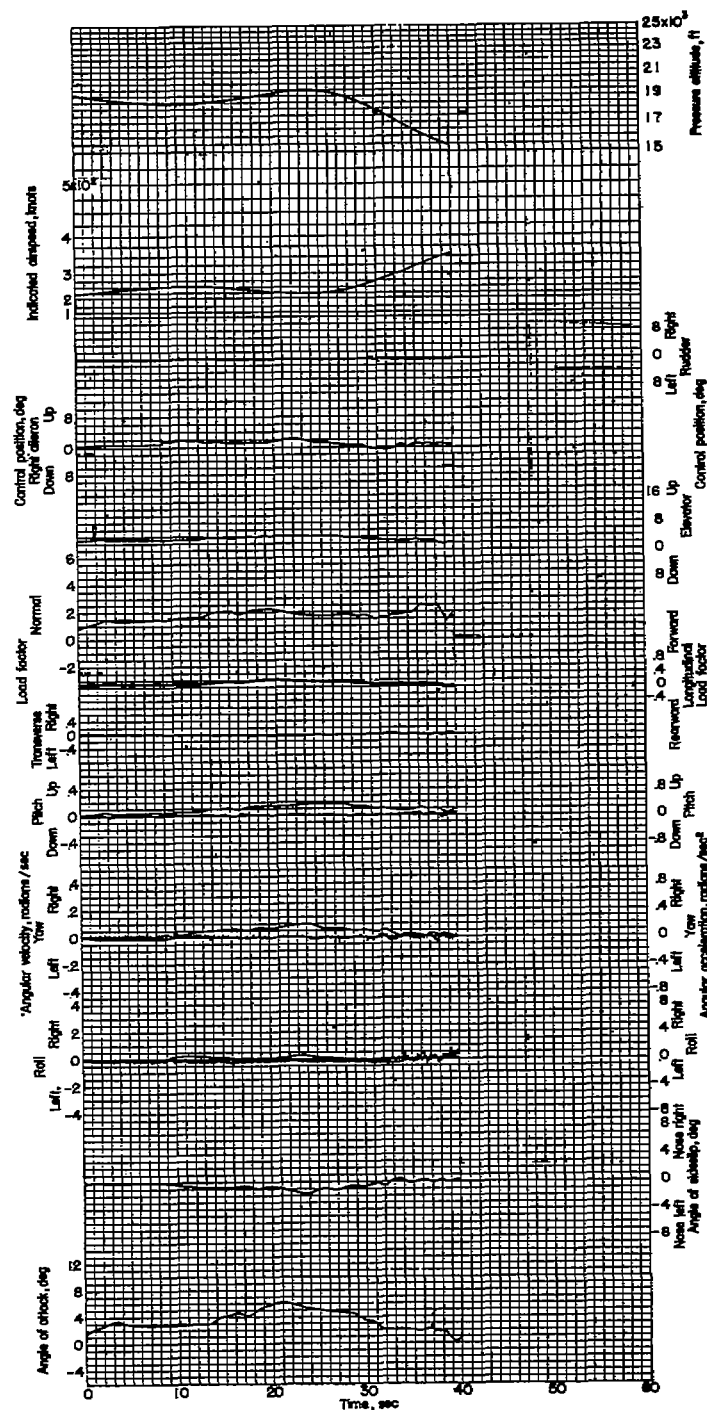


Figure 146.- Right roll entry into a dive. Pilot E wearing anti-gravity suit; airplane weight, 12,460 pounds; center of gravity at 27.8 percent M.A.C.

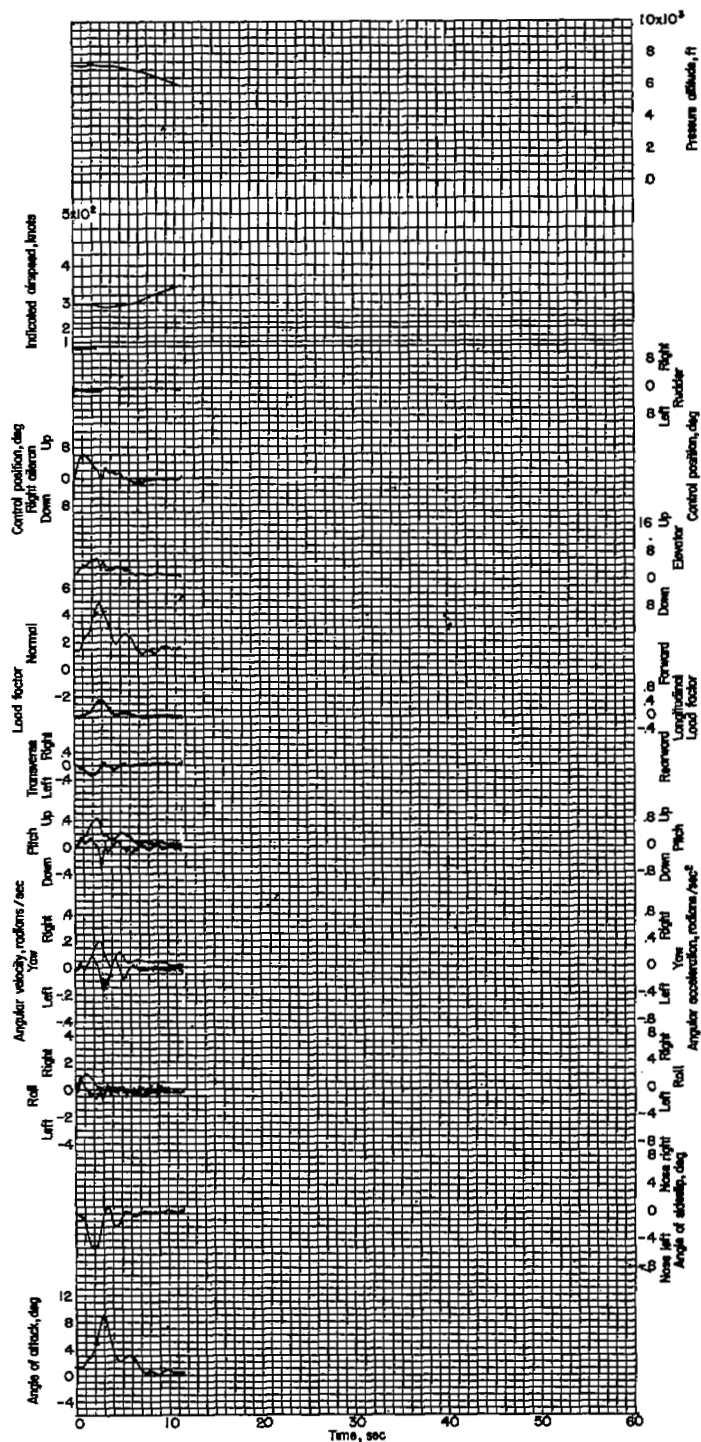


Figure 147.- Right roll entry into a dive. Pilot G; airplane weight, 12,610 pounds; center of gravity at 27.7 percent M.A.C.

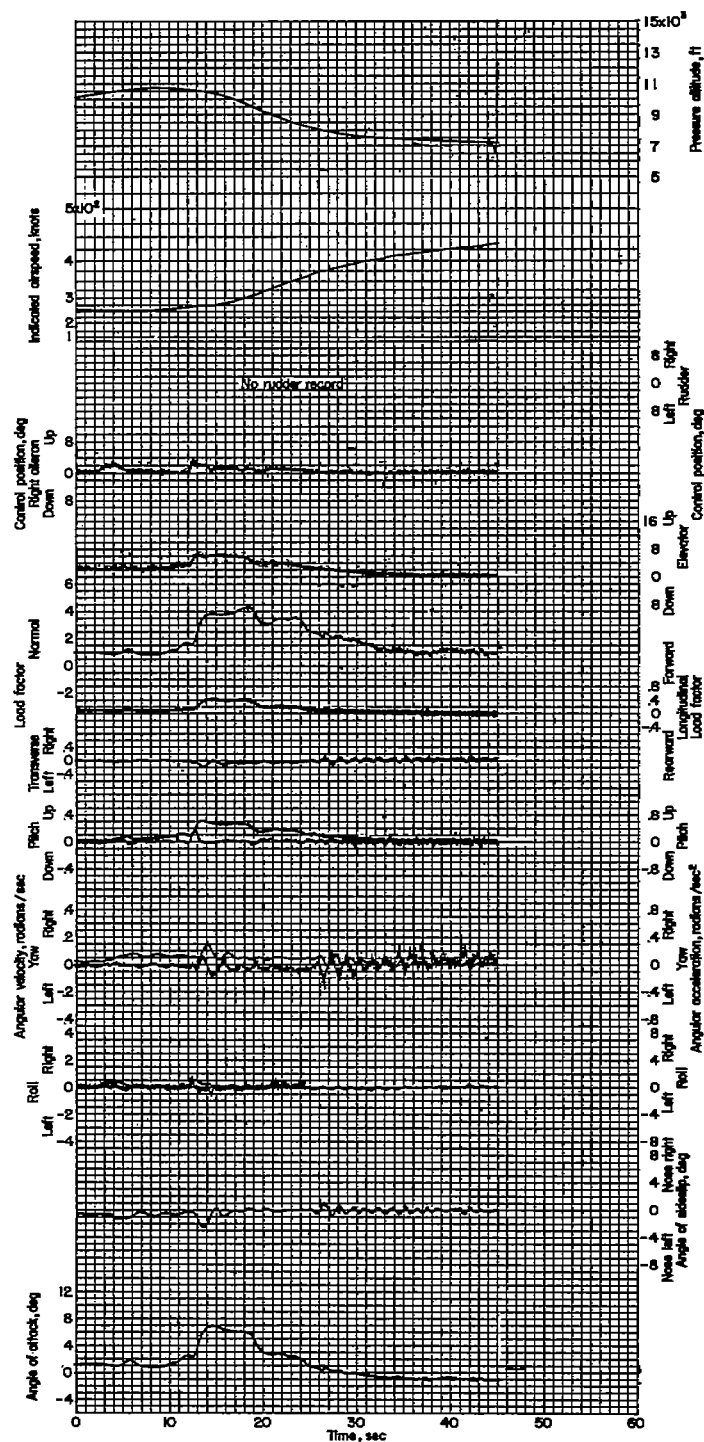


Figure 148.- Right roll entry into a dive. Pilot G; airplane weight, 12,050 pounds; center of gravity at 27.0 percent M.A.C.

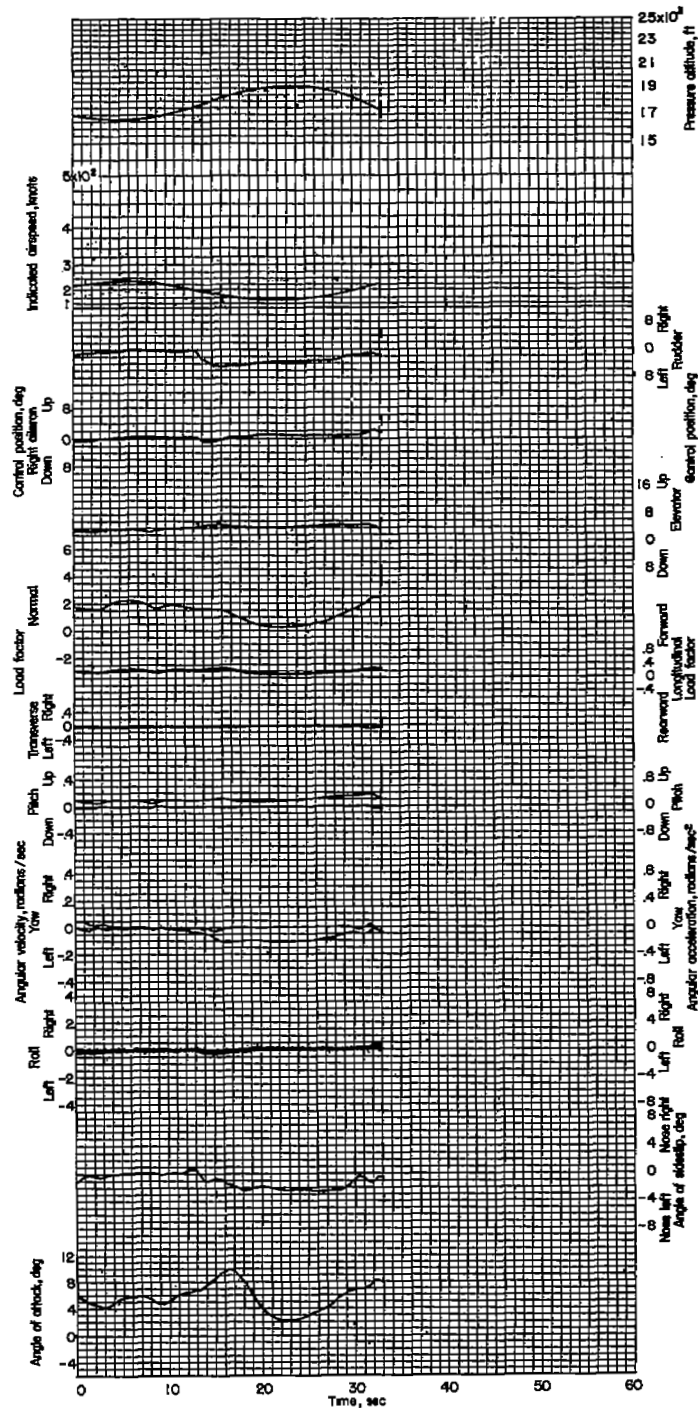


Figure 149.- Left roll entry into a dive. Pilot A; airplane weight, 12,510 pounds; center of gravity at 27.8 percent M.A.C.



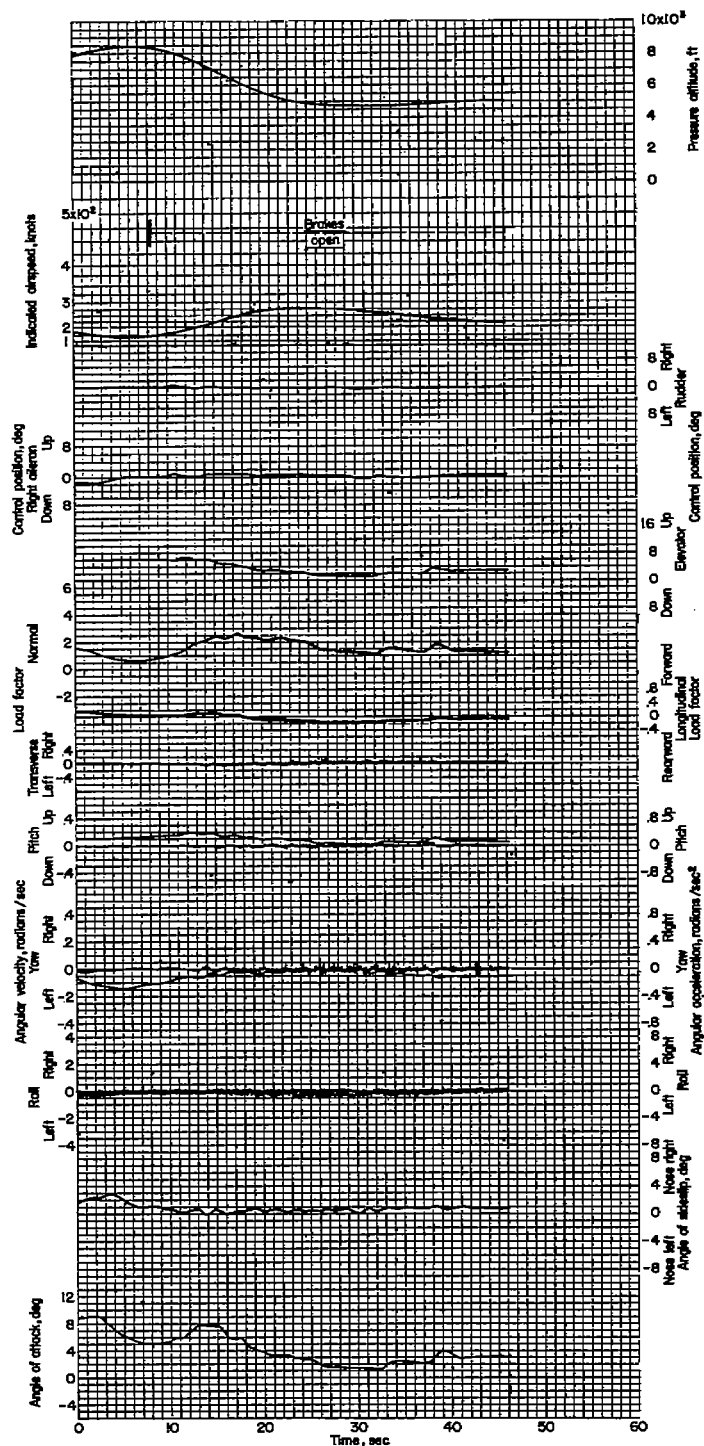


Figure 150.- Left roll entry into a dive. Pilot A; airplane weight, 11,500 pounds; center of gravity at 25.9 percent M.A.C.

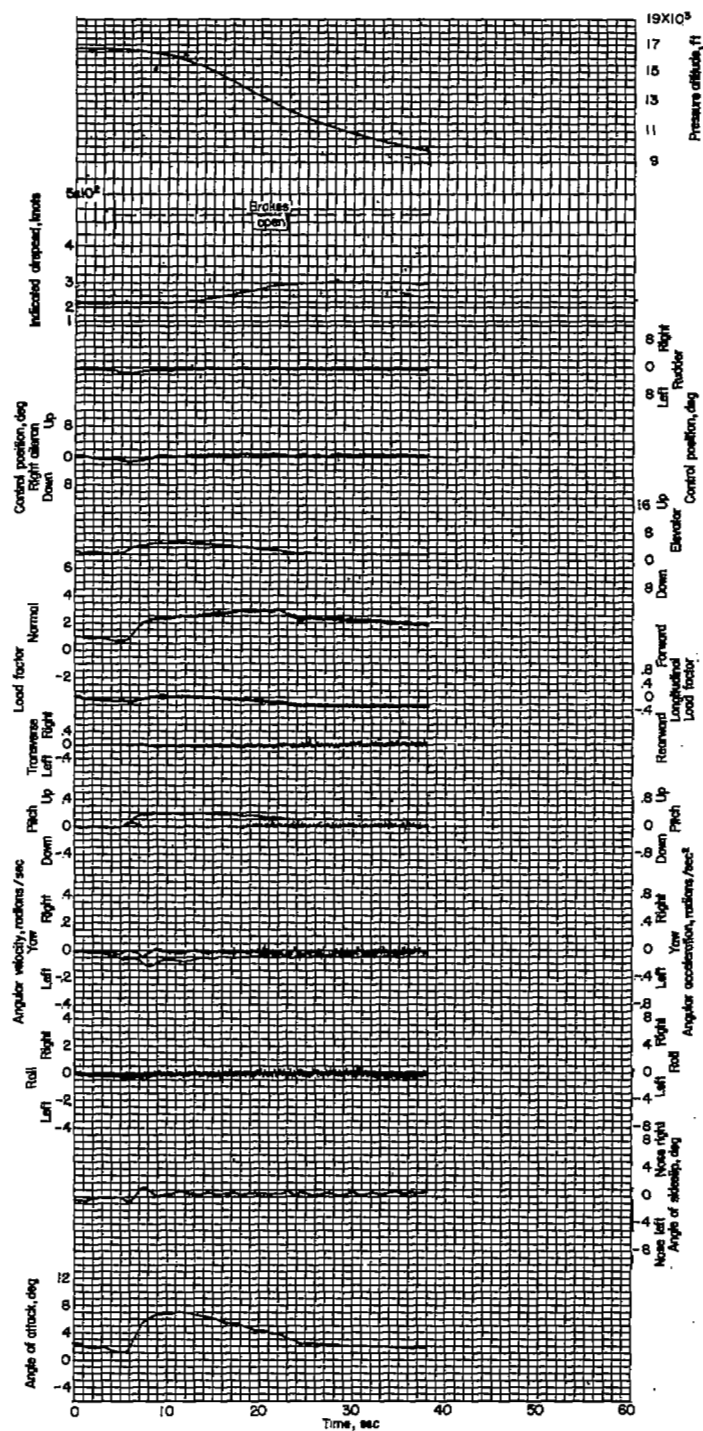


Figure 151.- Left roll entry into a dive. Pilot A; airplane weight, 11,620 pounds; center of gravity at 26.1 percent M.A.C.



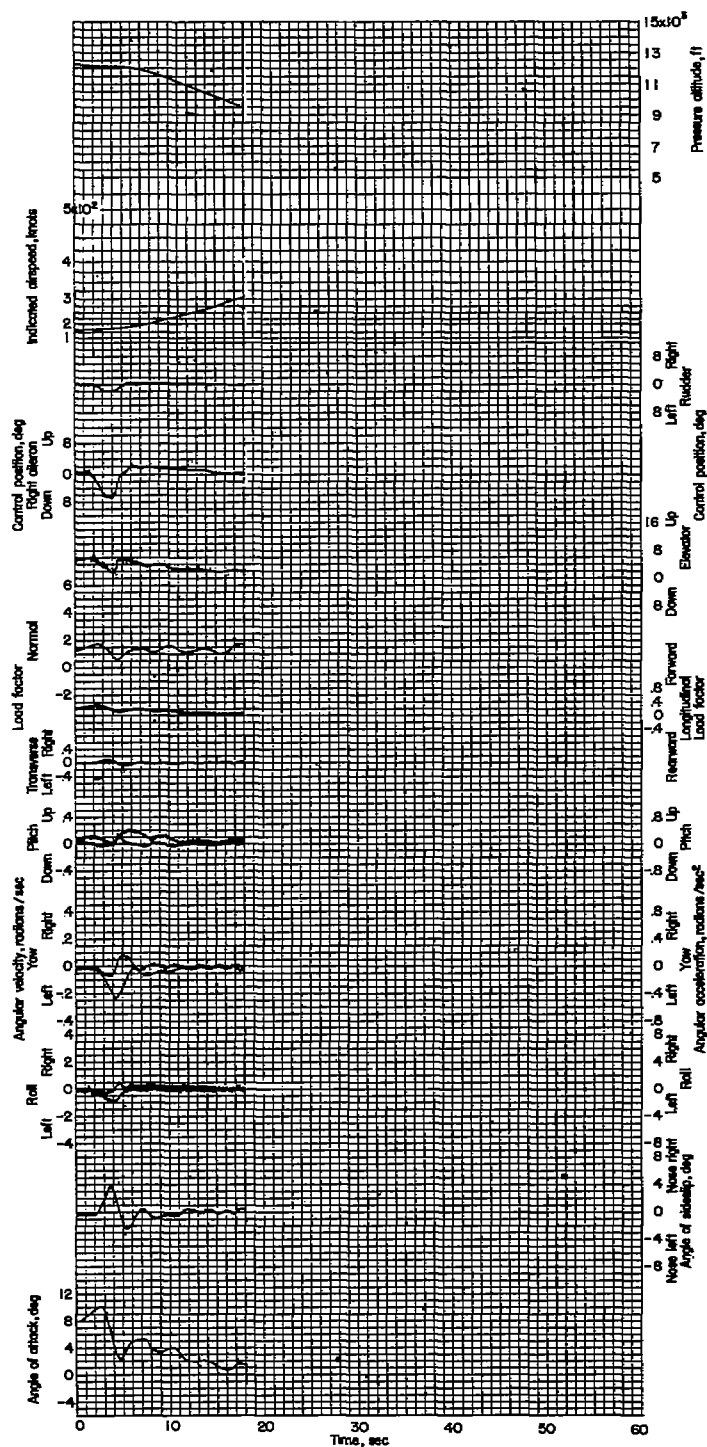


Figure 152.-, Left roll entry into a dive. Pilot A wearing anti-gravity suit; airplane weight, 11,970 pounds; center of gravity at 26.8 percent M.A.C.

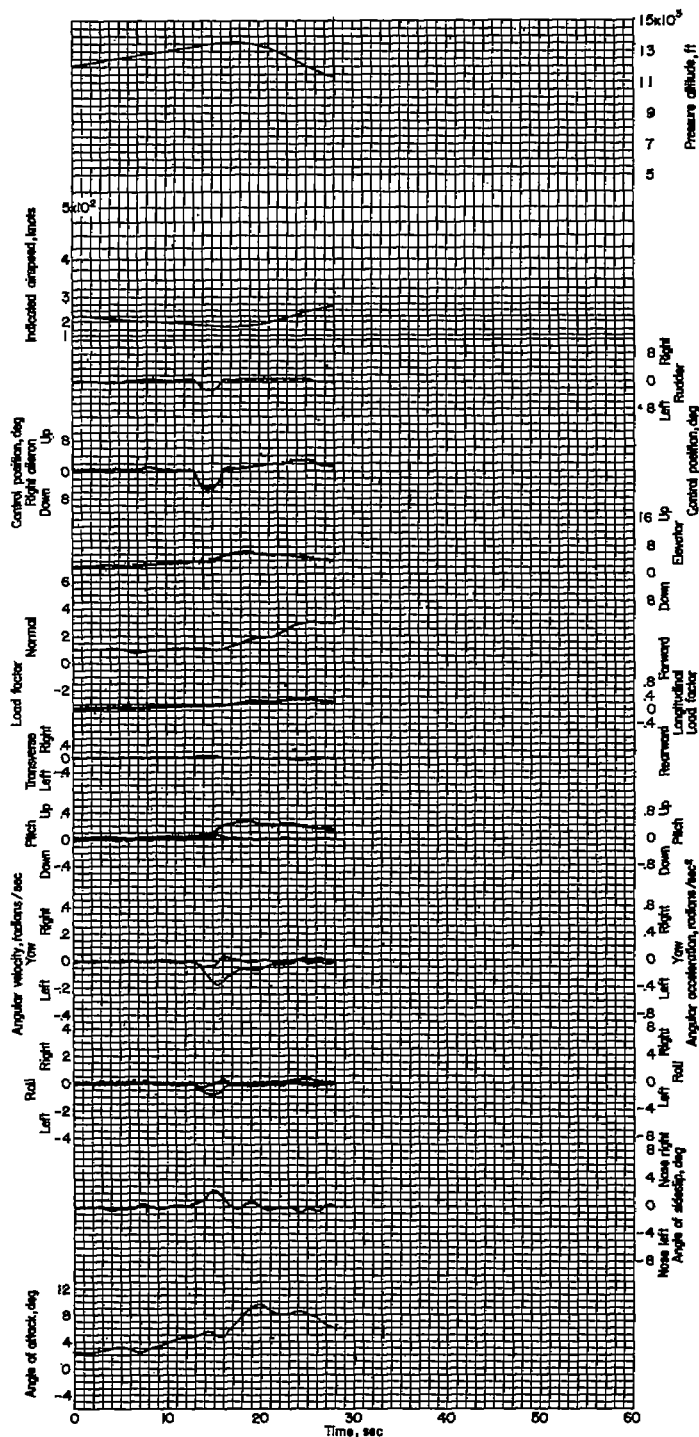


Figure 153.- Left roll entry into a dive. Pilot A wearing anti-gravity suit; airplane weight, 12,340 pounds; center of gravity at 27.5 percent M.A.C.

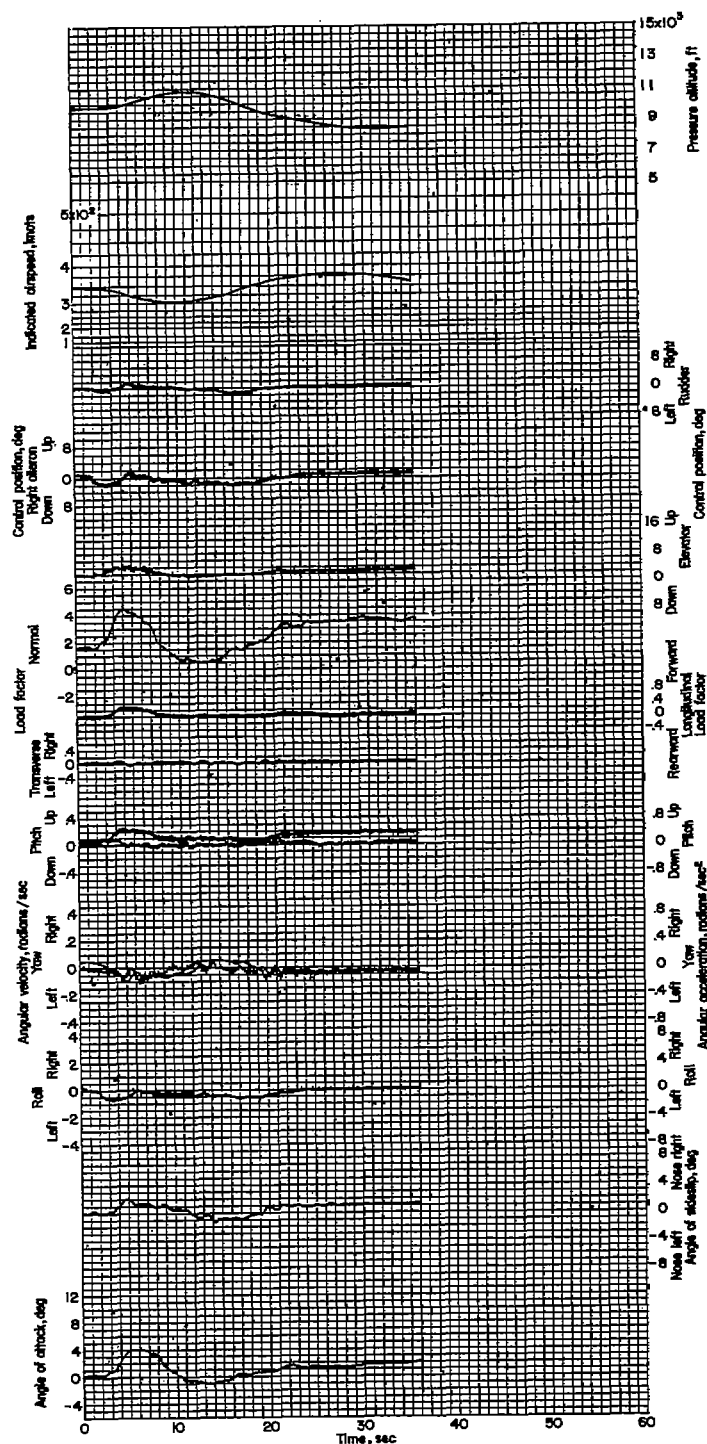


Figure 154.- Left roll entry into a dive. Pilot A wearing anti-gravity suit; airplane weight, 12,100 pounds; center of gravity at 27.1 per-cent M.A.C.

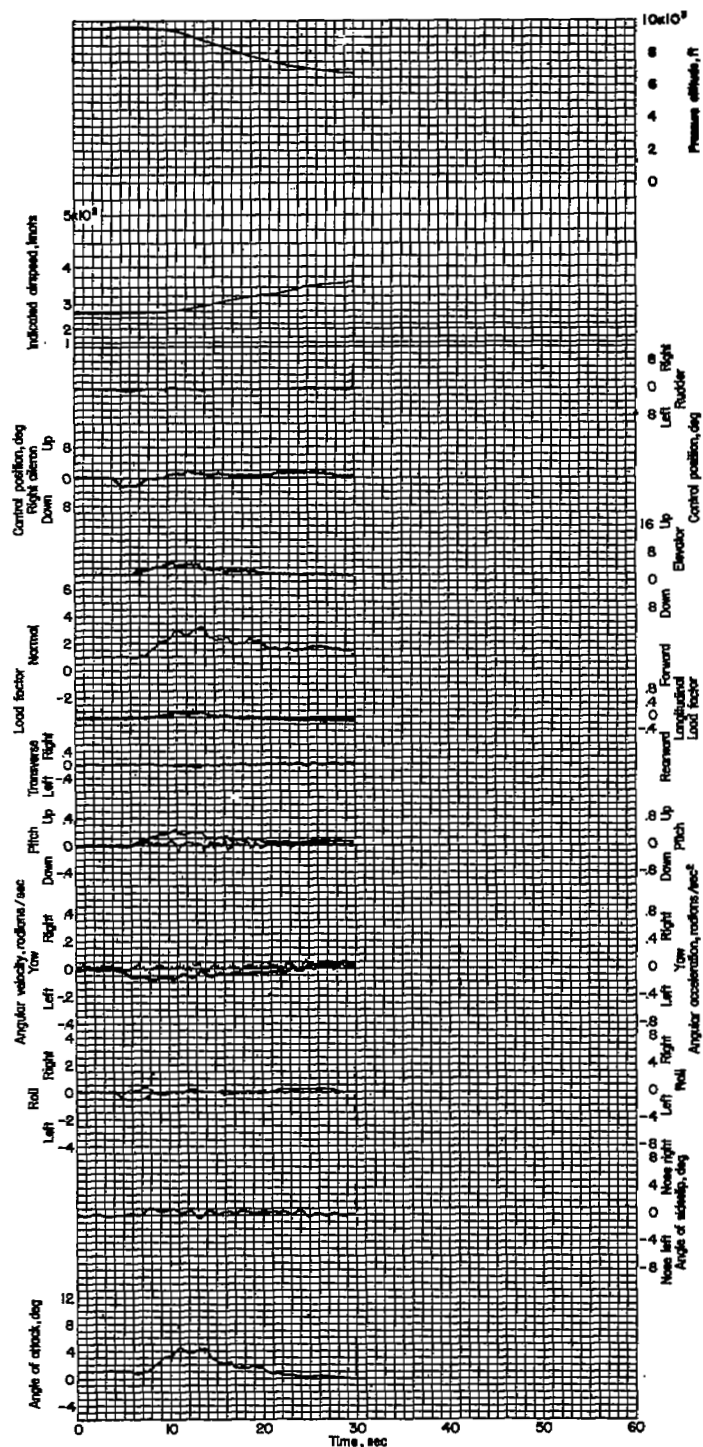
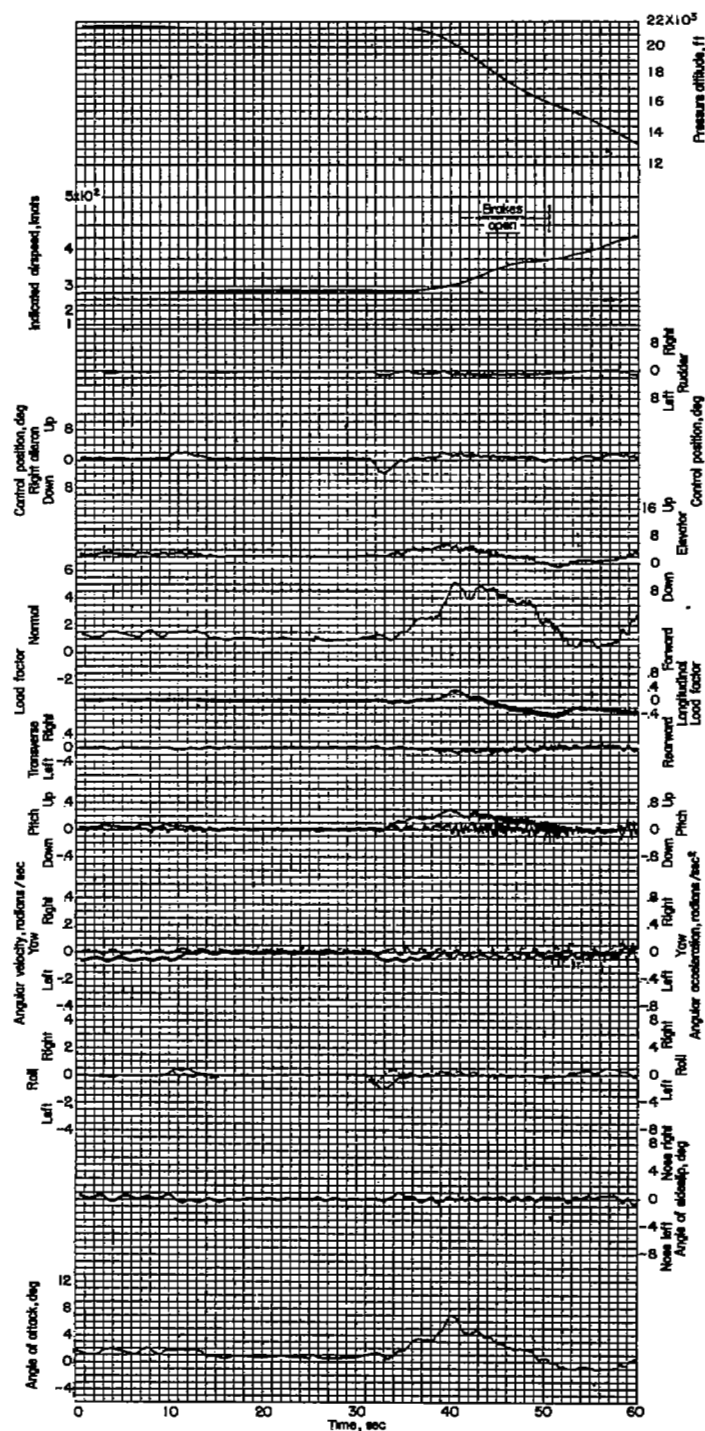


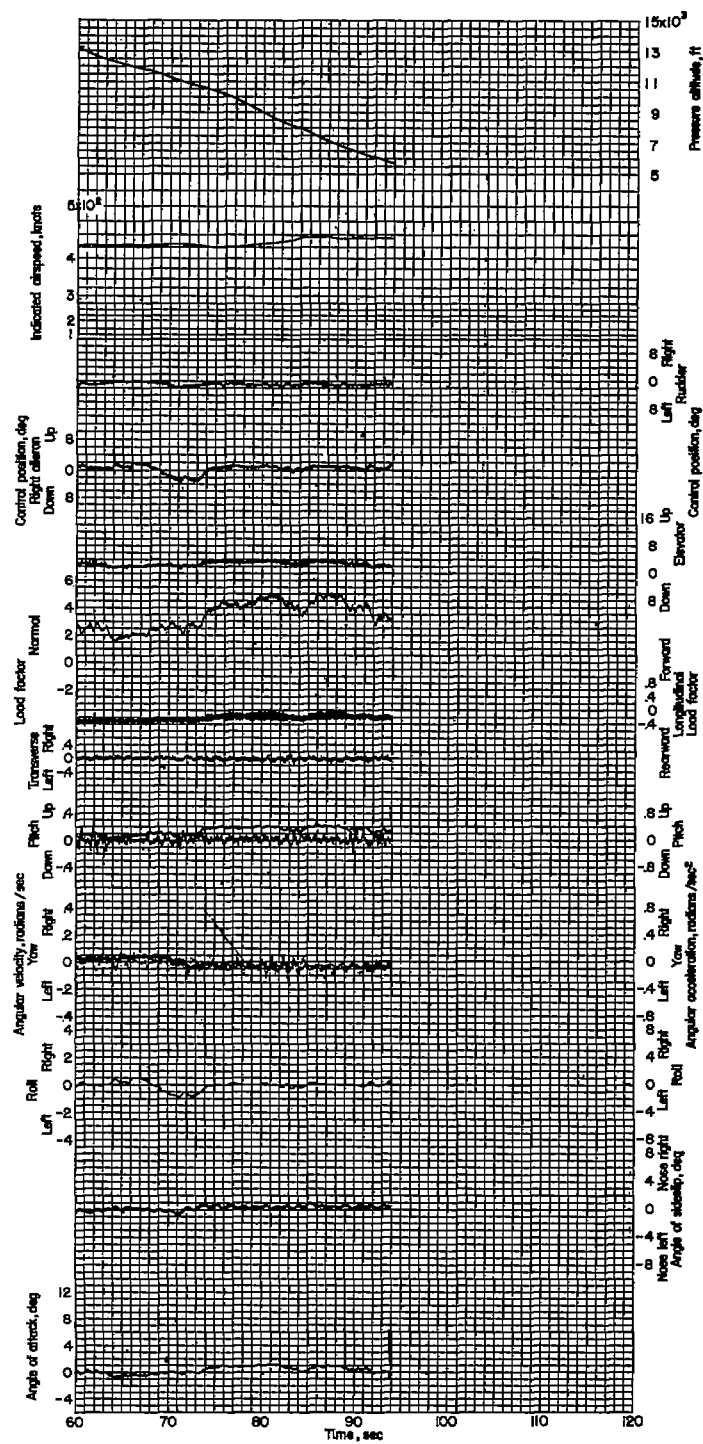
Figure 155.- Left roll entry into a dive. Pilot C with radar observer; airplane weight, 11,870 pounds; center of gravity at 25.3 percent M.A.C.



(a)



Figure 156.- Left roll entry into a dive. Pilot C with radar observer; airplane weight, 12,450 pounds; center of gravity 27.5 percent M.A.C.



(b)

Figure 156.- Concluded.



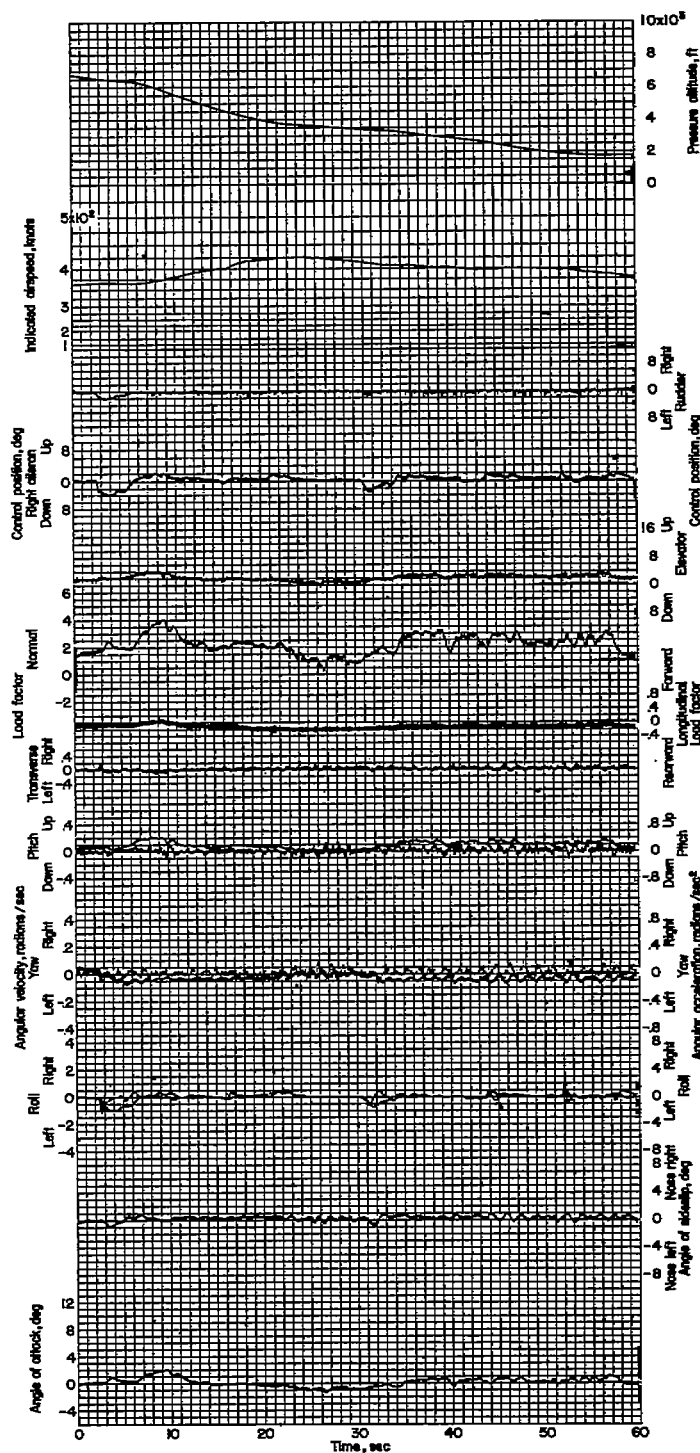


Figure 157.- Left roll entry into a dive. Pilot C with radar observer; airplane weight, 11,845 pounds; center of gravity at 25.2 percent M.A.C.

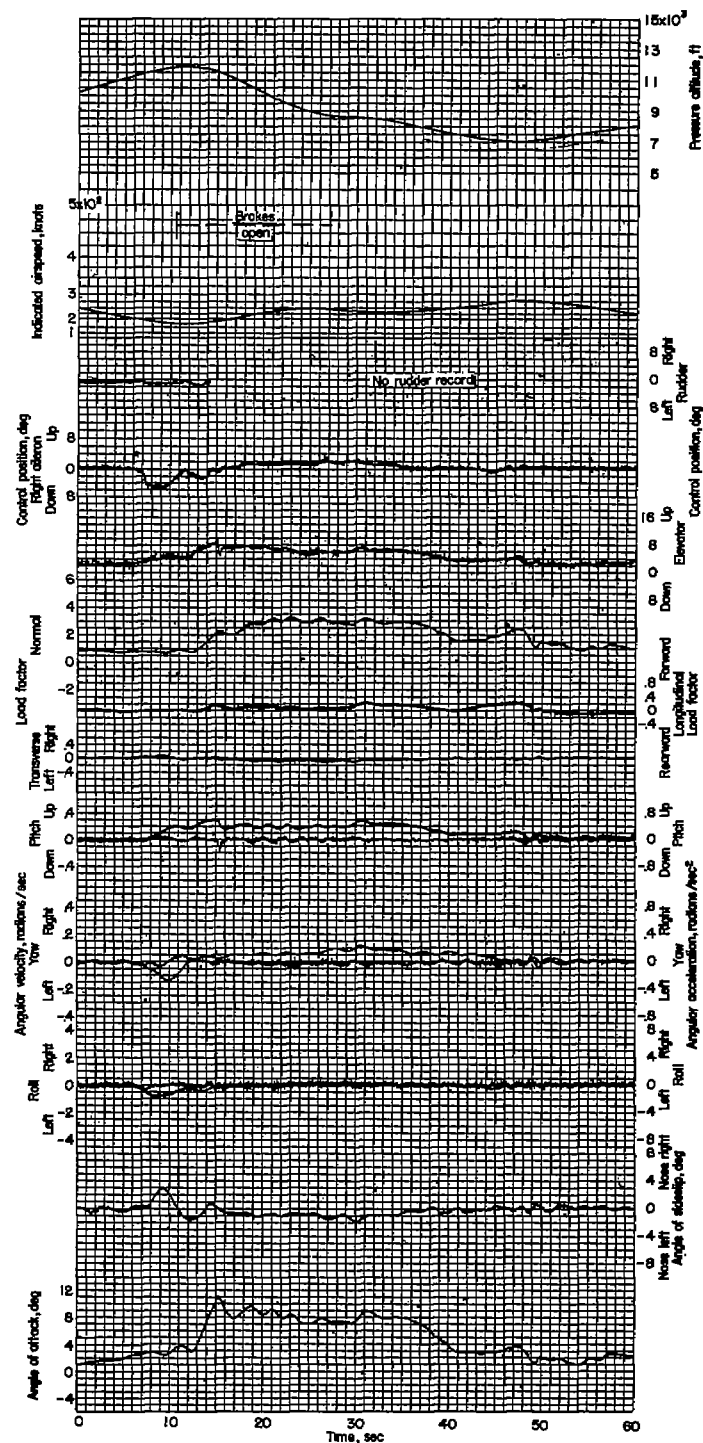


Figure 158.- Left roll entry into a dive. Pilot G; airplane weight, 12,230 pounds; center of gravity at 27.3 percent M.A.C.



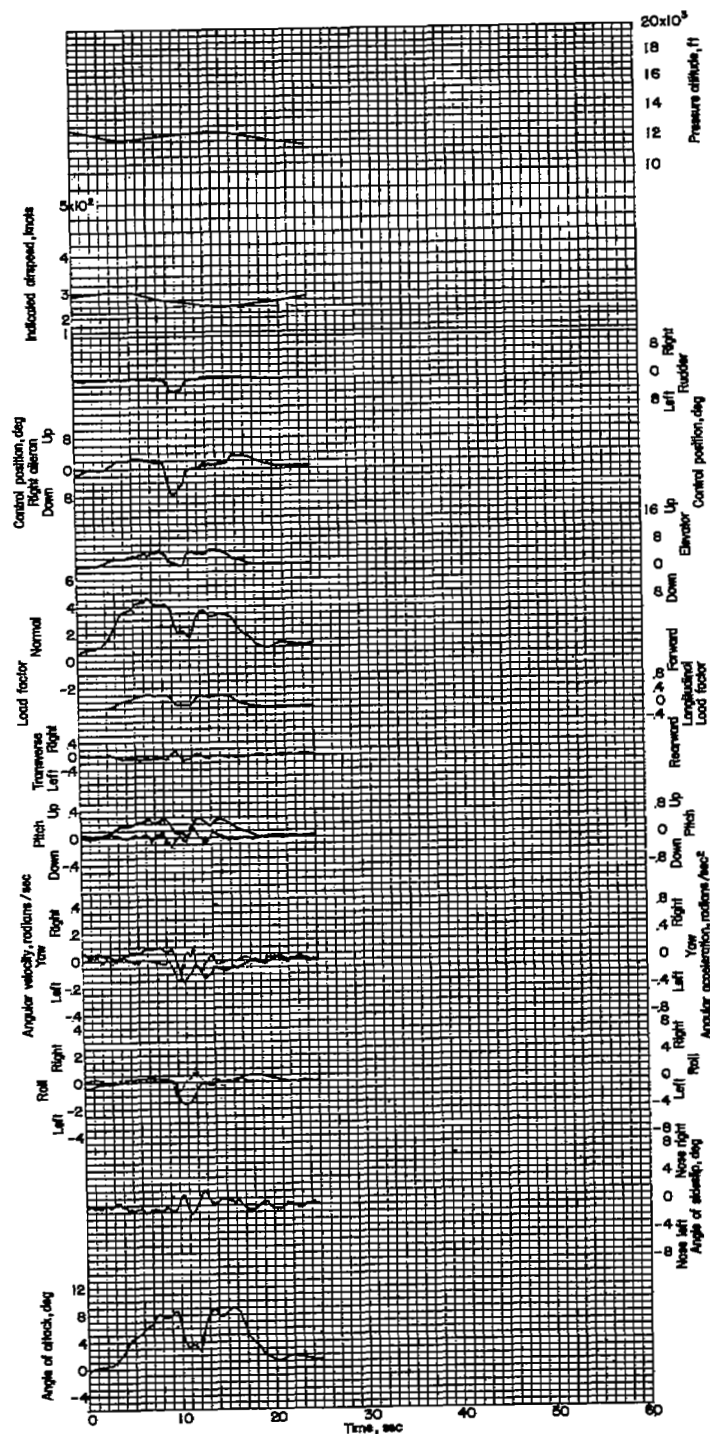
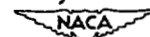


Figure 159.- Wing-over. Pilot A; airplane weight, 12,155 pounds; center of gravity at 27.2 percent M.A.C.



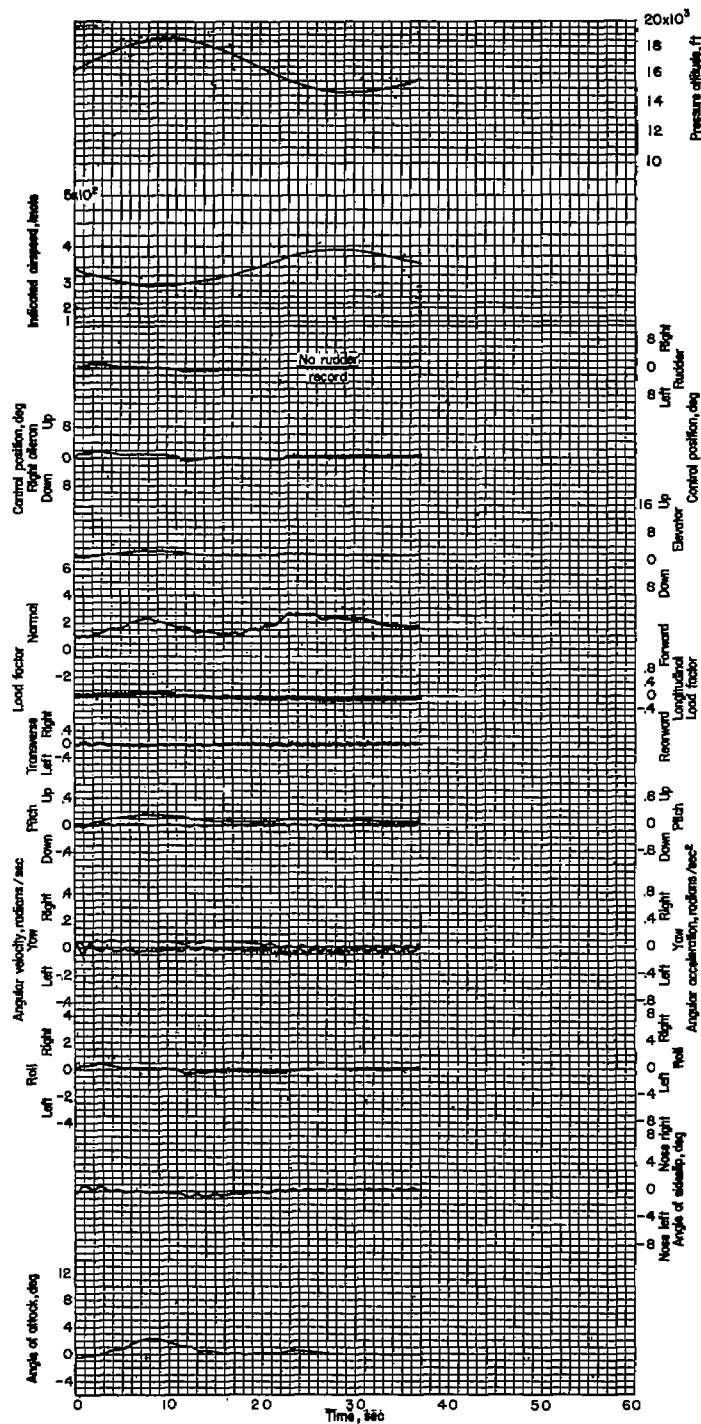


Figure 160.- Wing-over. Pilot A; airplane weight, 11,770 pounds; center of gravity at 26.4 percent M.A.C.



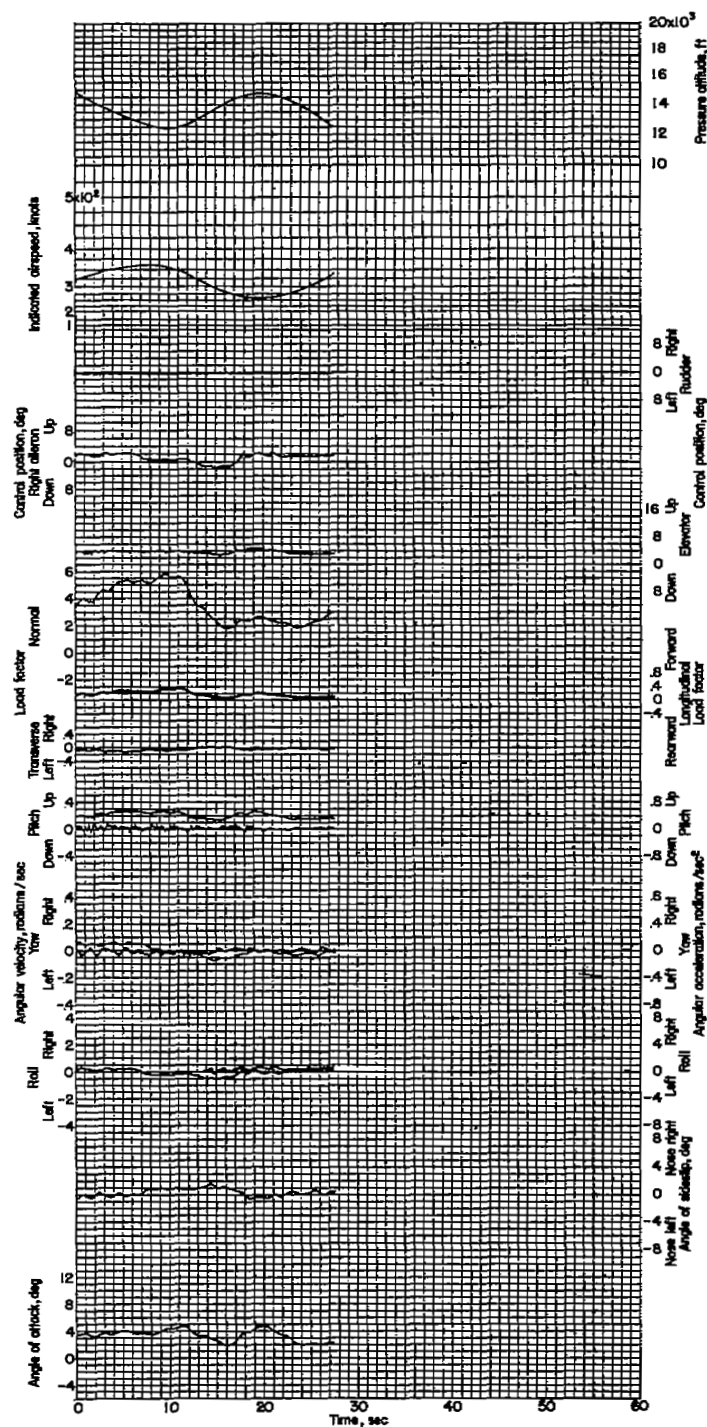


Figure 161.- Wing-over. Pilot B with radar observer; airplane weight, 12,050 pounds; center of gravity at 27.0 percent M.A.C.

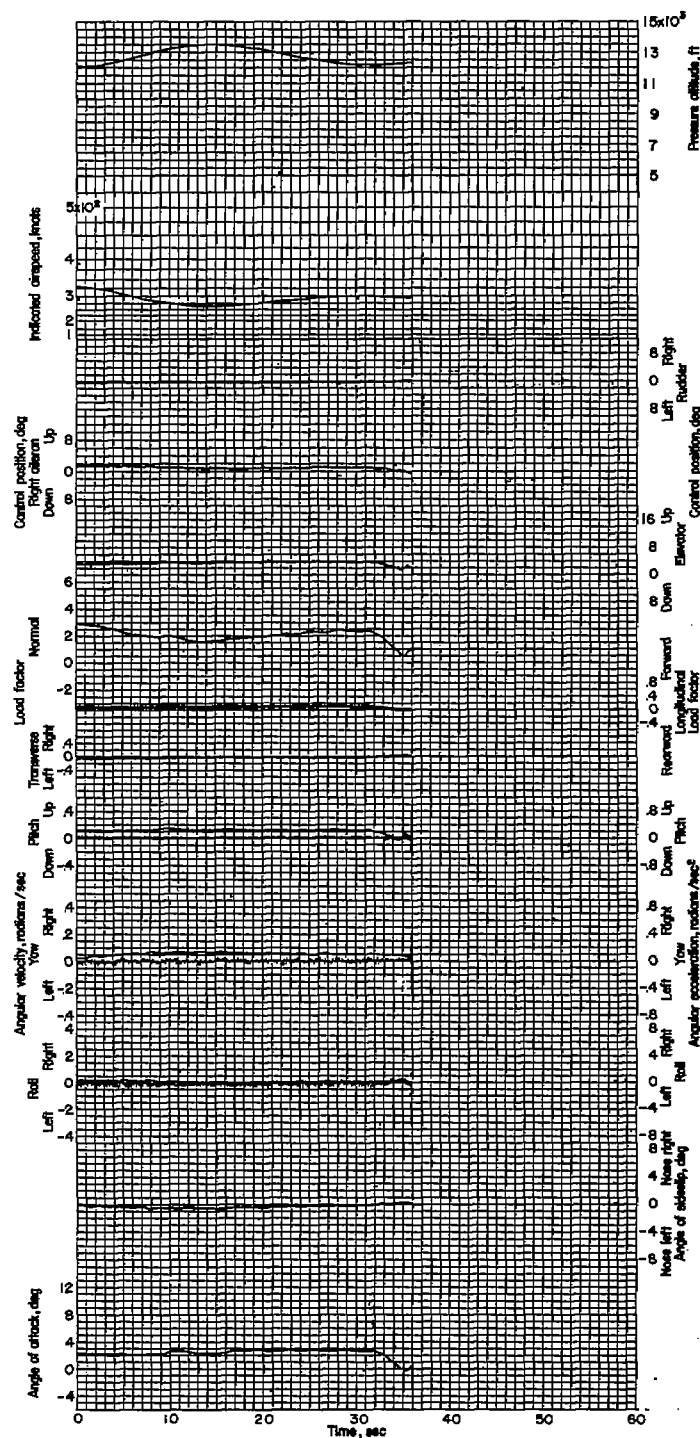
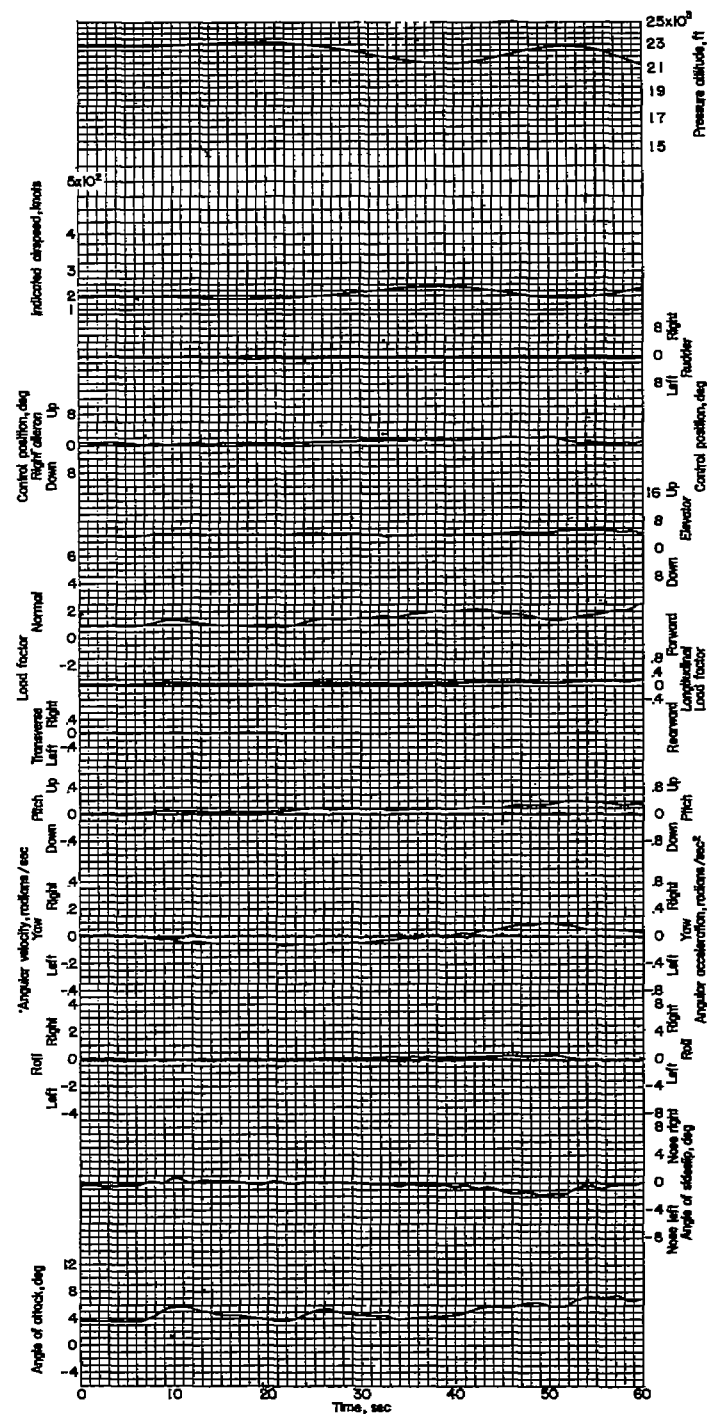


Figure 162.- Wing-over. Pilot E wearing anti-gravity suit; airplane weight, 11,680 pounds; center of gravity 26.3 percent M.A.C.

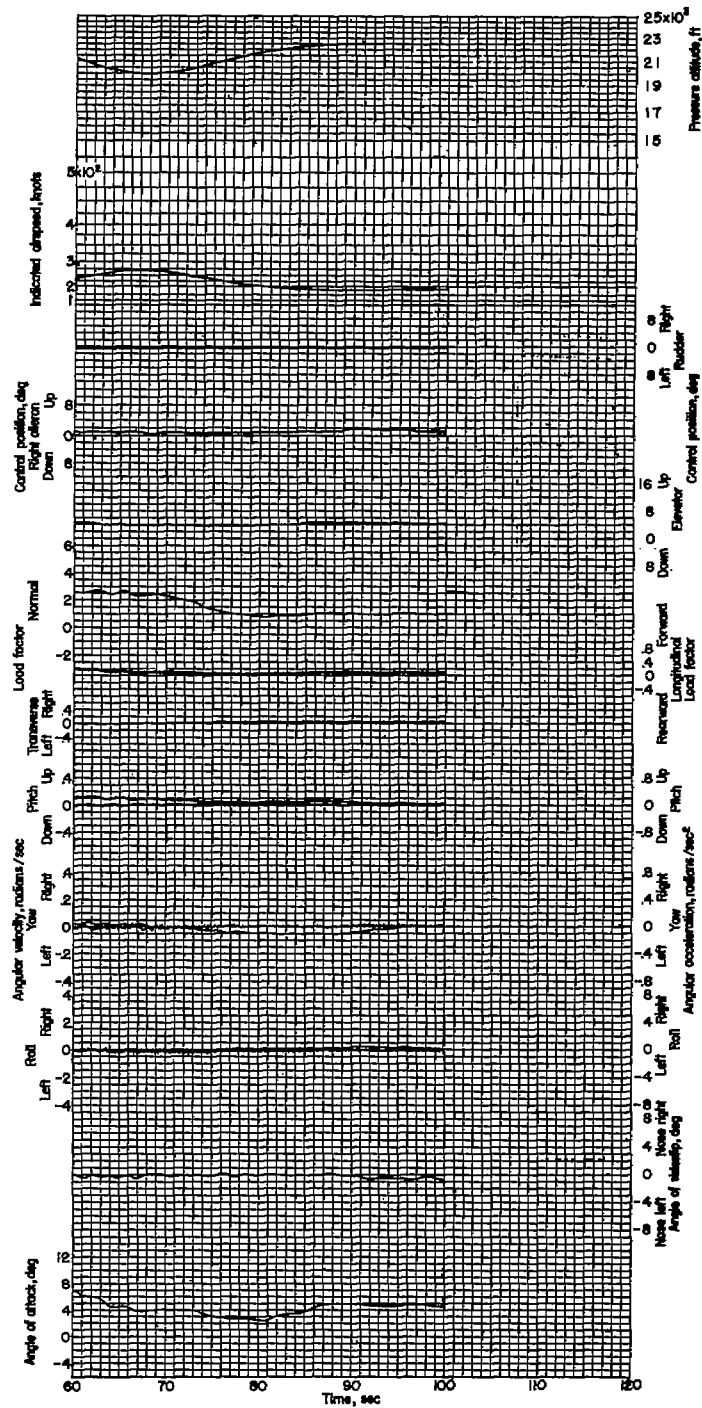
NACA



(a)



Figure 163.- Wing-over. Pilot E wearing anti-gravity suit; airplane weight, 12,000 pounds; center of gravity 26.9 percent M.A.C.



(b)



Figure 163.- Concluded.

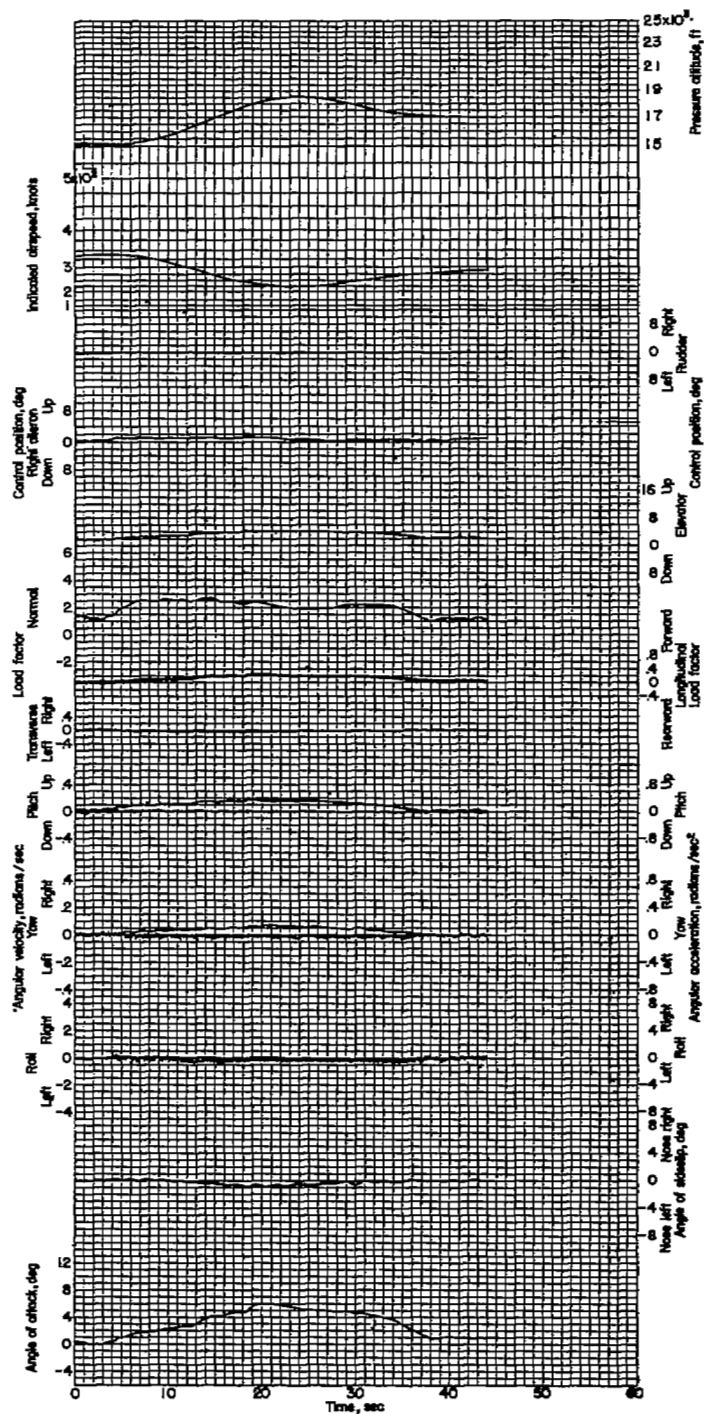


Figure 164.- Wing-over. Pilot E wearing anti-gravity suit; airplane weight, 12,320 pounds; center of gravity at 27.5 percent M.A.C.



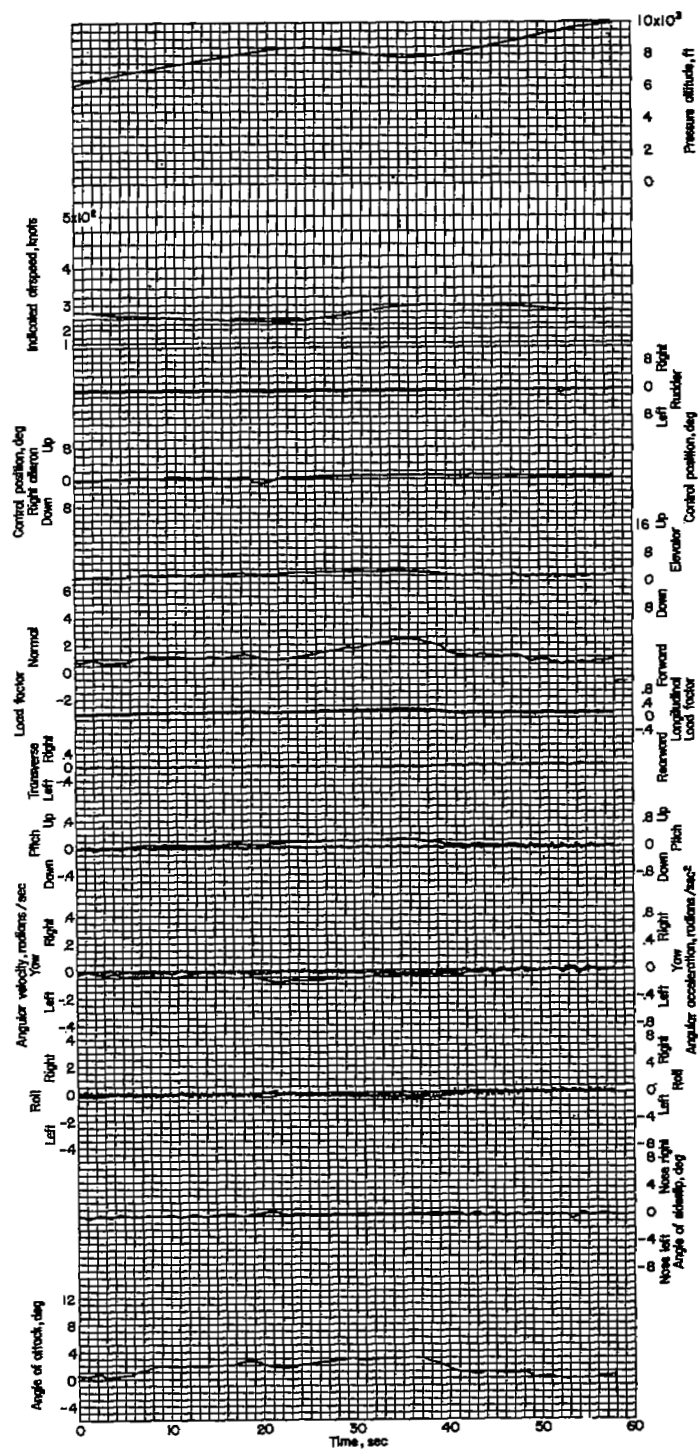


Figure 165.- Wing-over. Pilot F wearing anti-gravity suit; airplane weight, 12,780 pounds; center of gravity at 27.7 percent M.A.C.

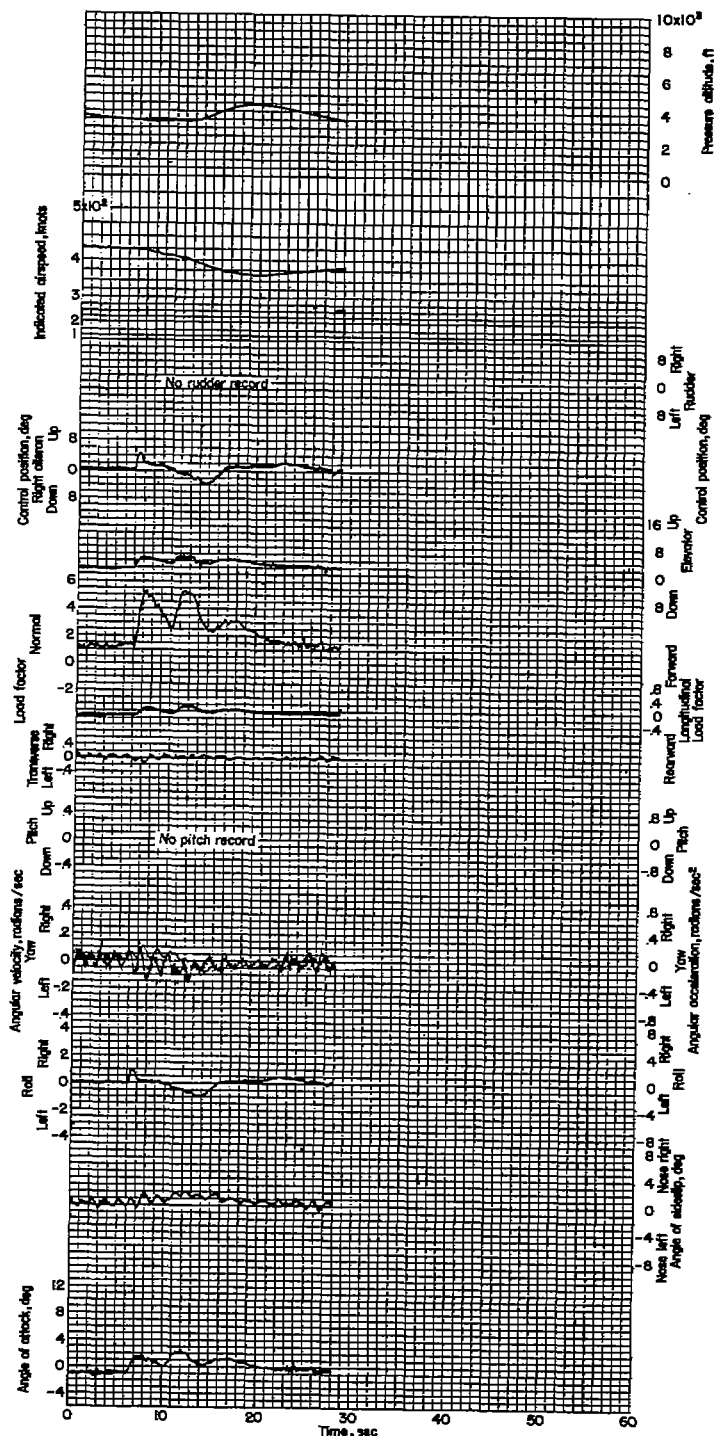
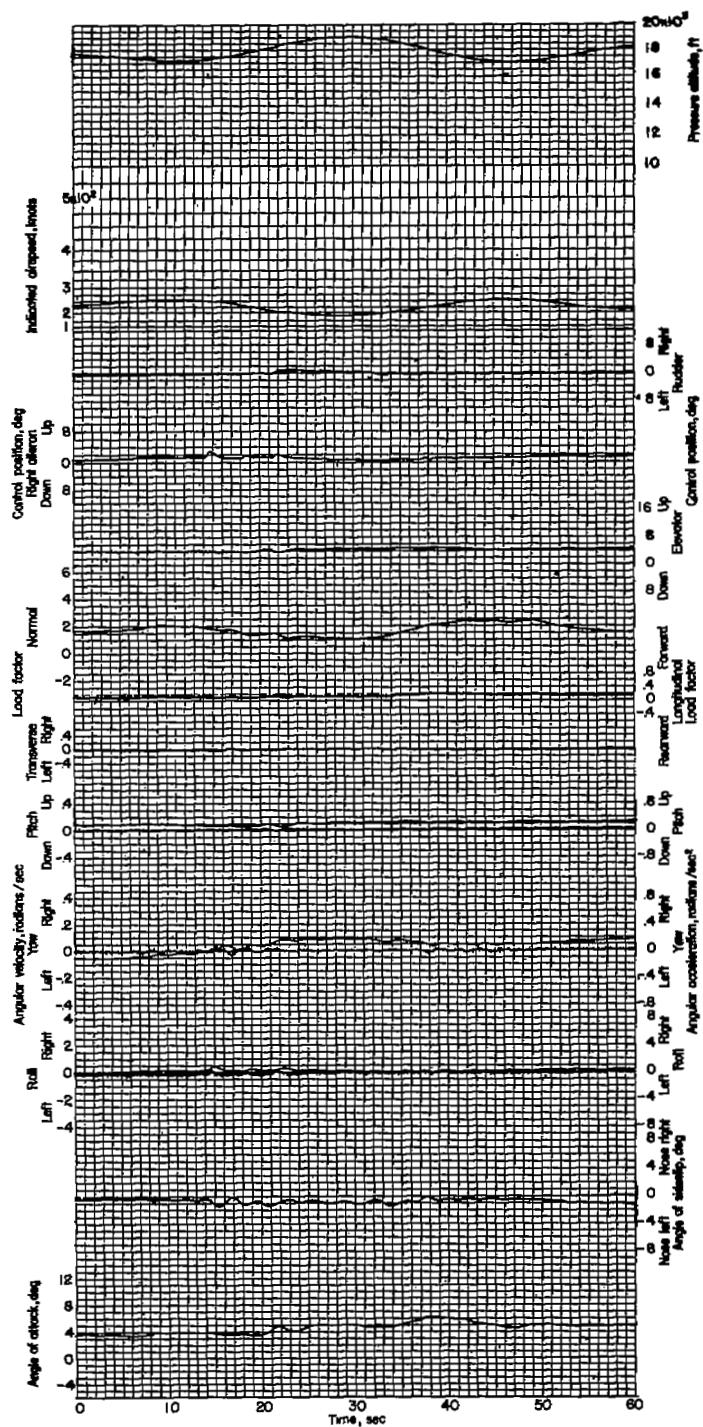


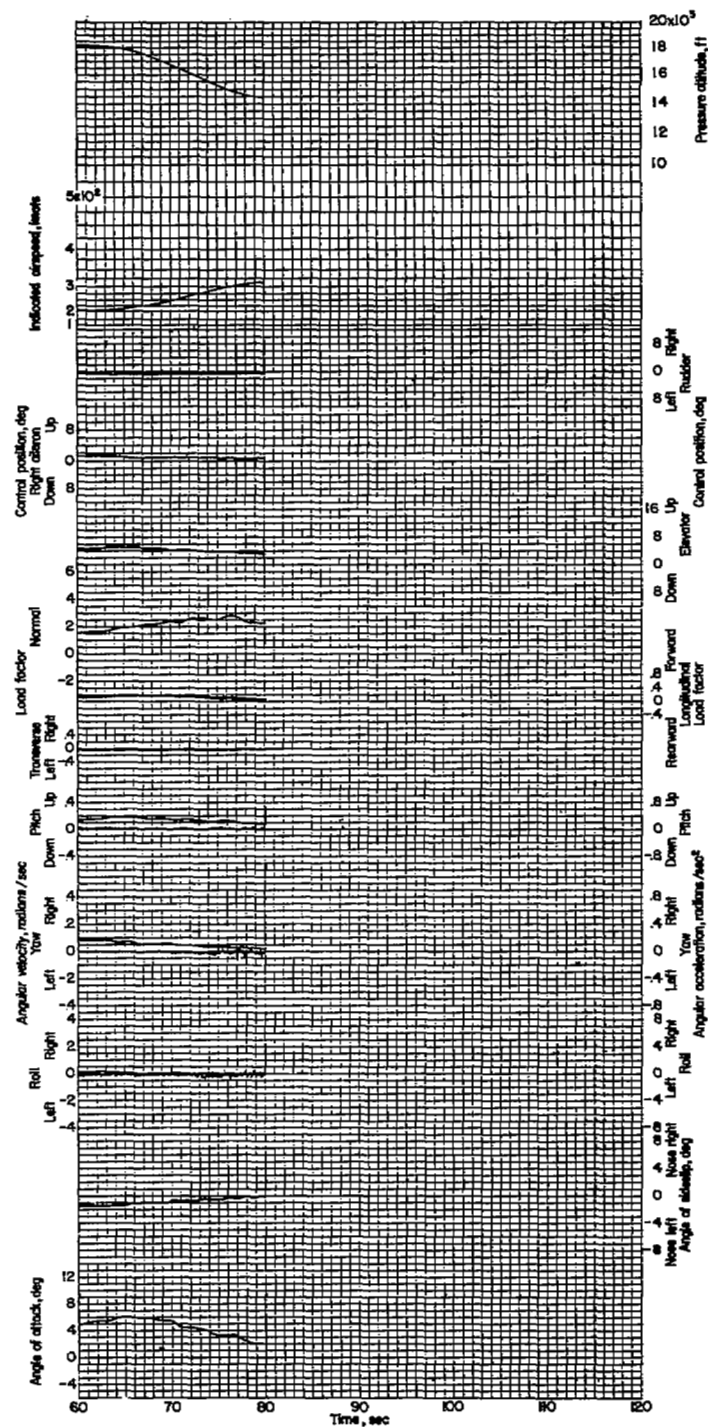
Figure 166.- Wing-over. Pilot G with radar observer; airplane weight, 12,545 pounds; center of gravity at 26.6 percent M.A.C.



(a)



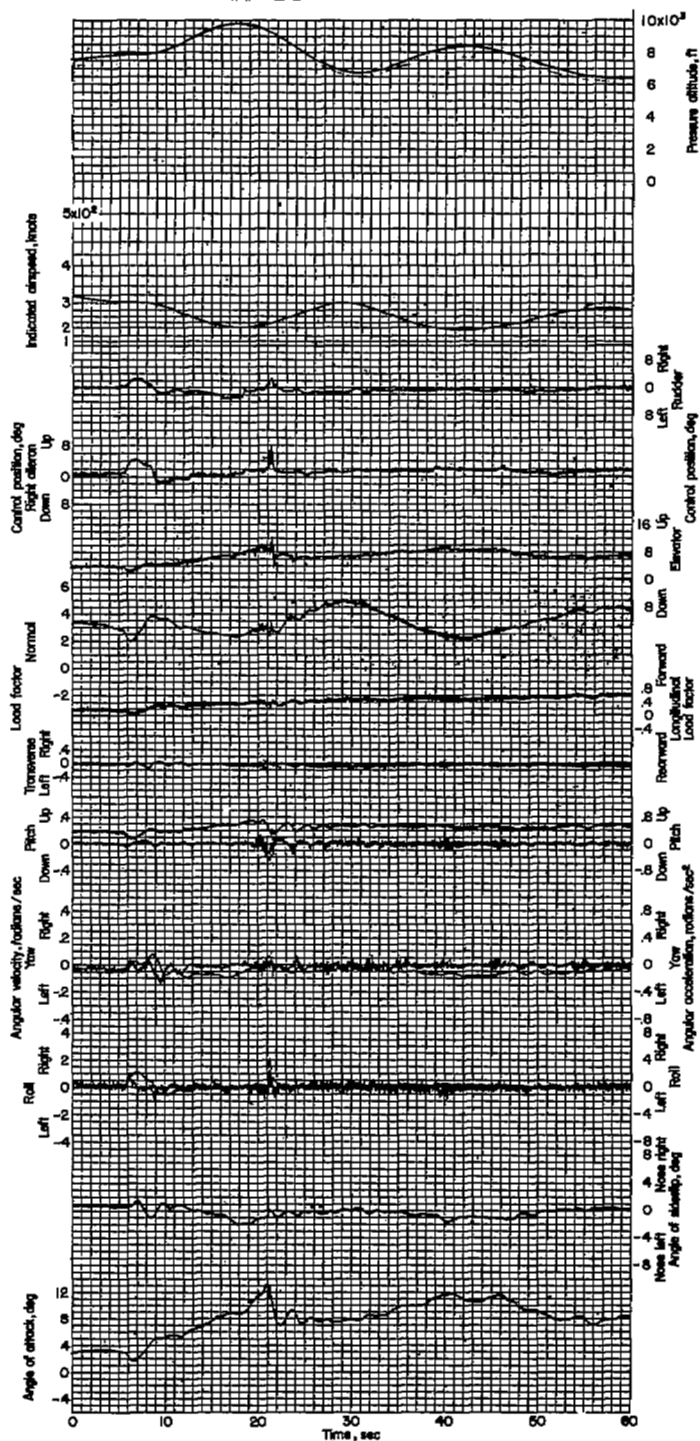
Figure 167.- Two wing-overs. Pilot E wearing anti-gravity suit; airplane weight, 11,760 pounds; center of gravity at 26.4 percent M.A.C.



(b)



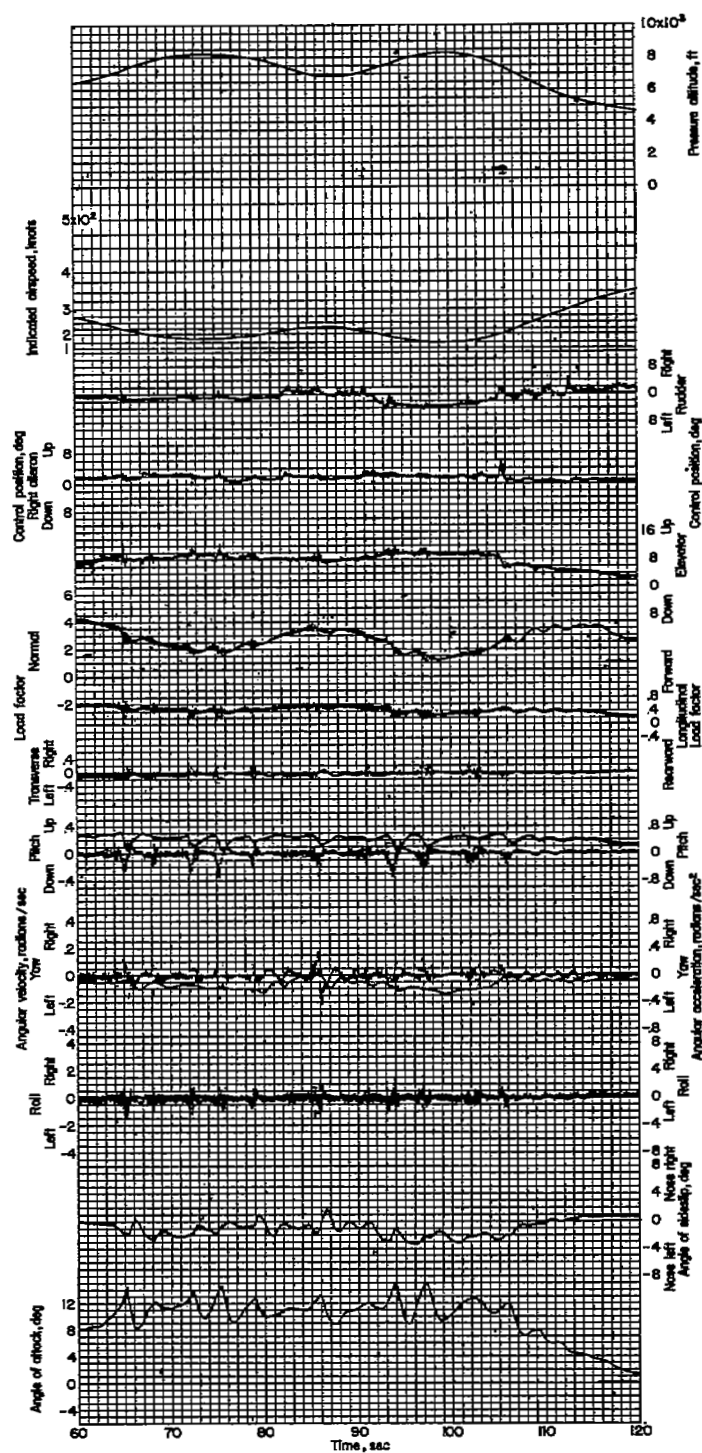
Figure 167.- Concluded.



(a)



Figure 168.- Series of wing-overs. Pilot A wearing anti-gravity suit; airplane weight, 11,740 pounds; center of gravity at 26.4 percent M.A.C.



(b)

Figure 168.- Concluded.



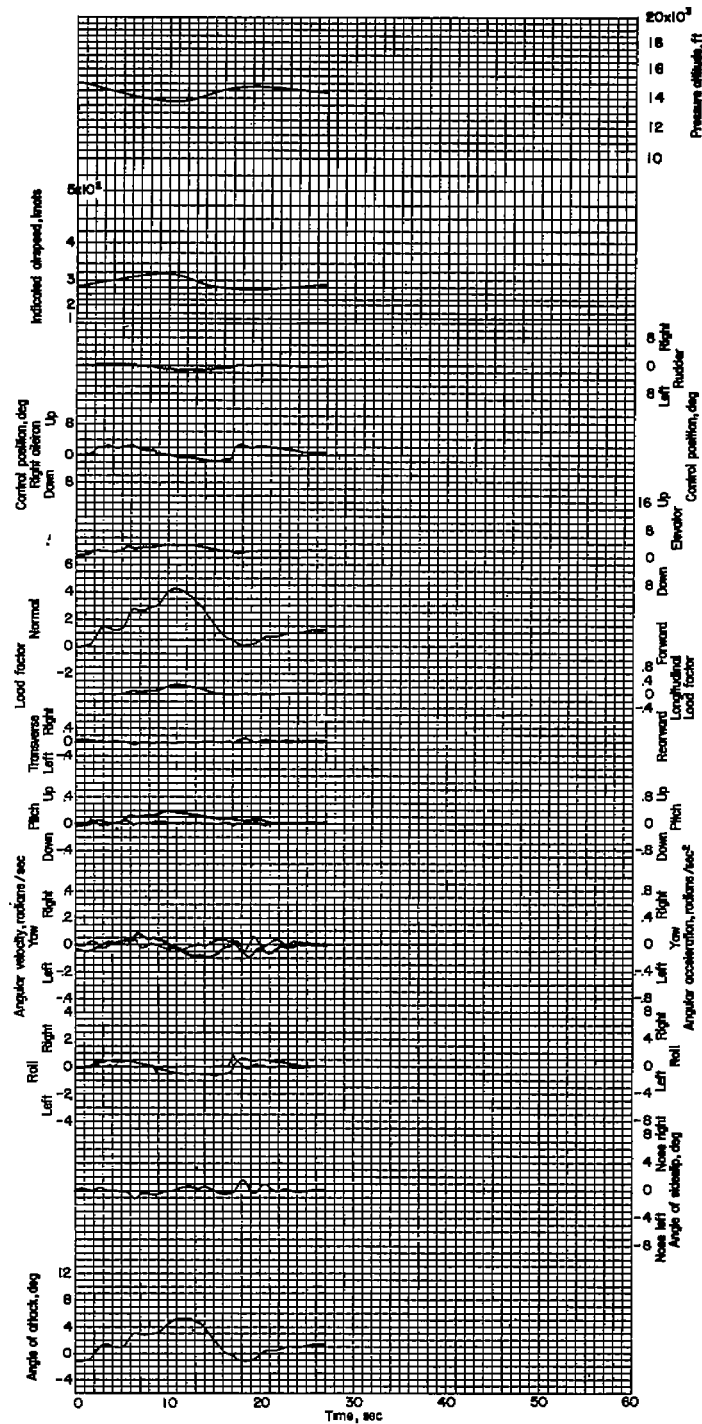


Figure 169.- Chandelle. Pilot A; airplane weight, 12,240 pounds; center of gravity at 27.4 percent M.A.C.



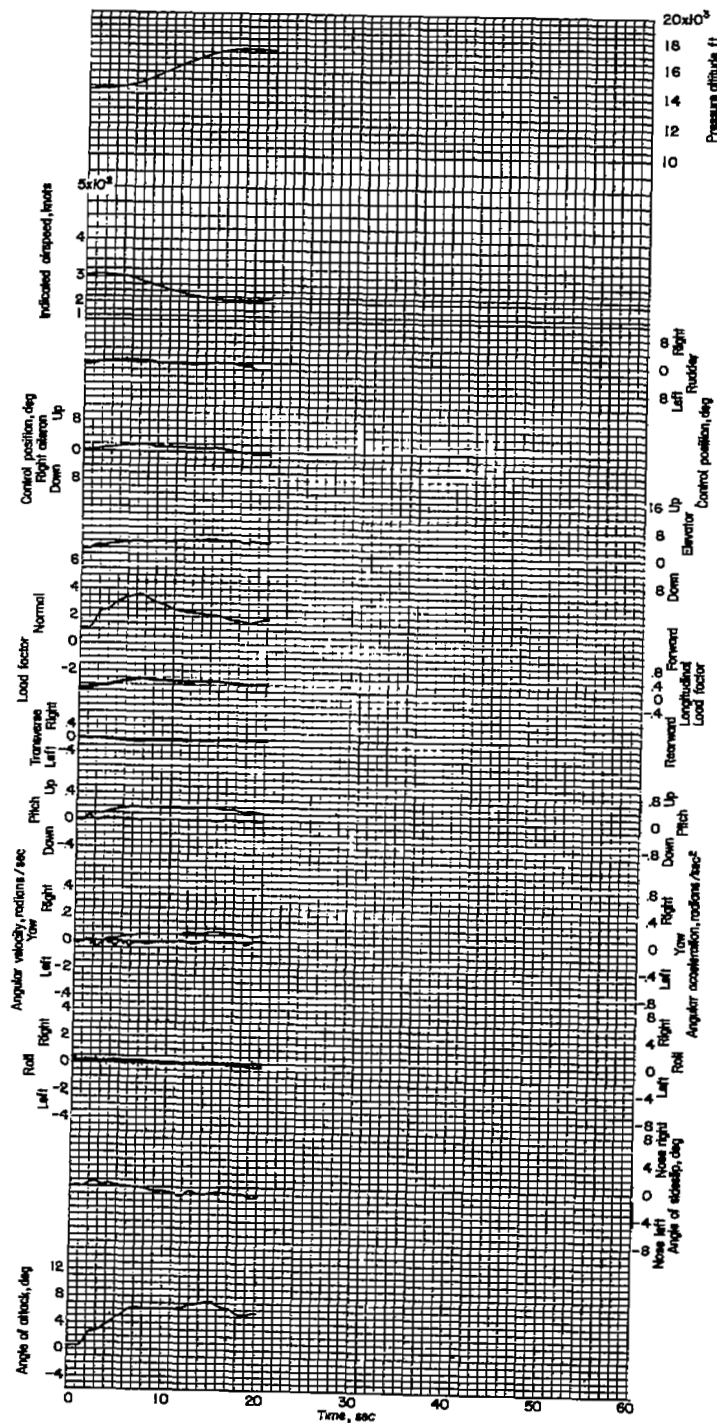
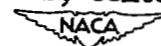


Figure 170.- Chandelle. Pilot A; airplane weight, 12,530 pounds; center of gravity at 27.8 percent M.A.C.



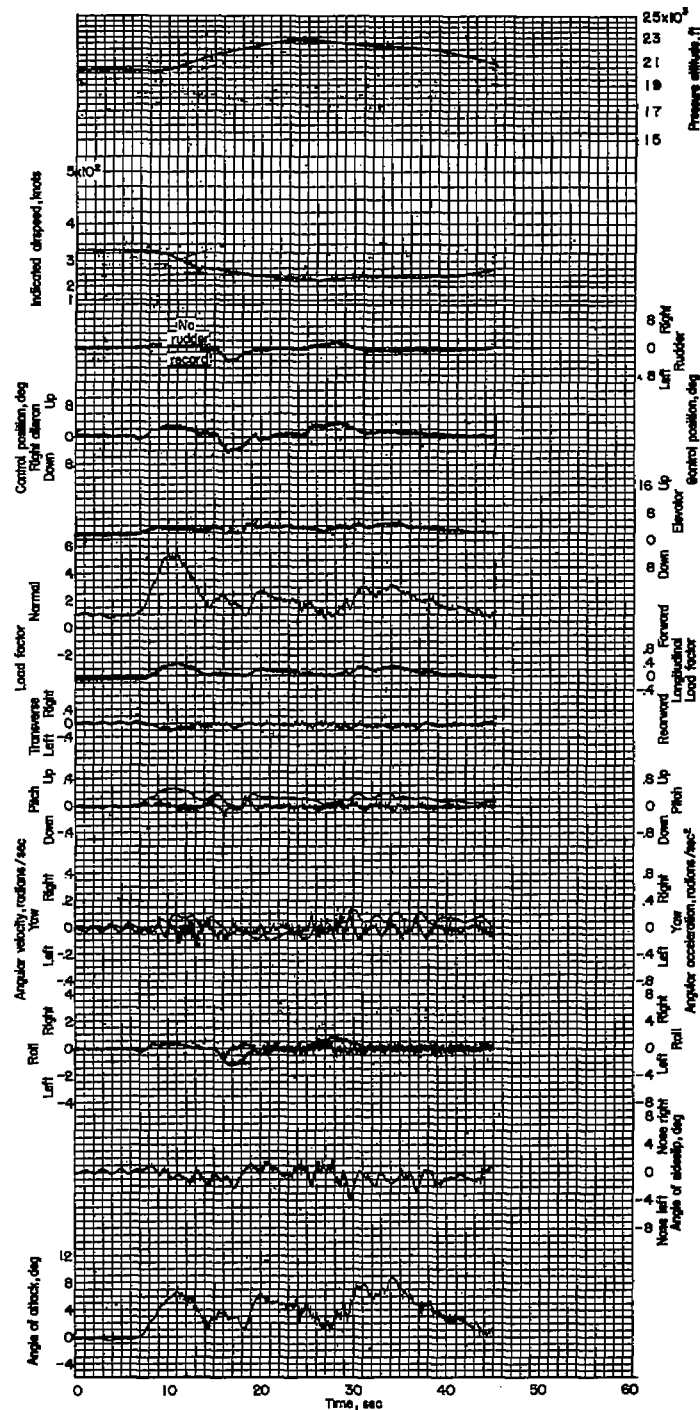


Figure 171.- Chandelle. Pilot A; airplane weight, 12,140 pounds; center of gravity at 27.2 percent M.A.C.

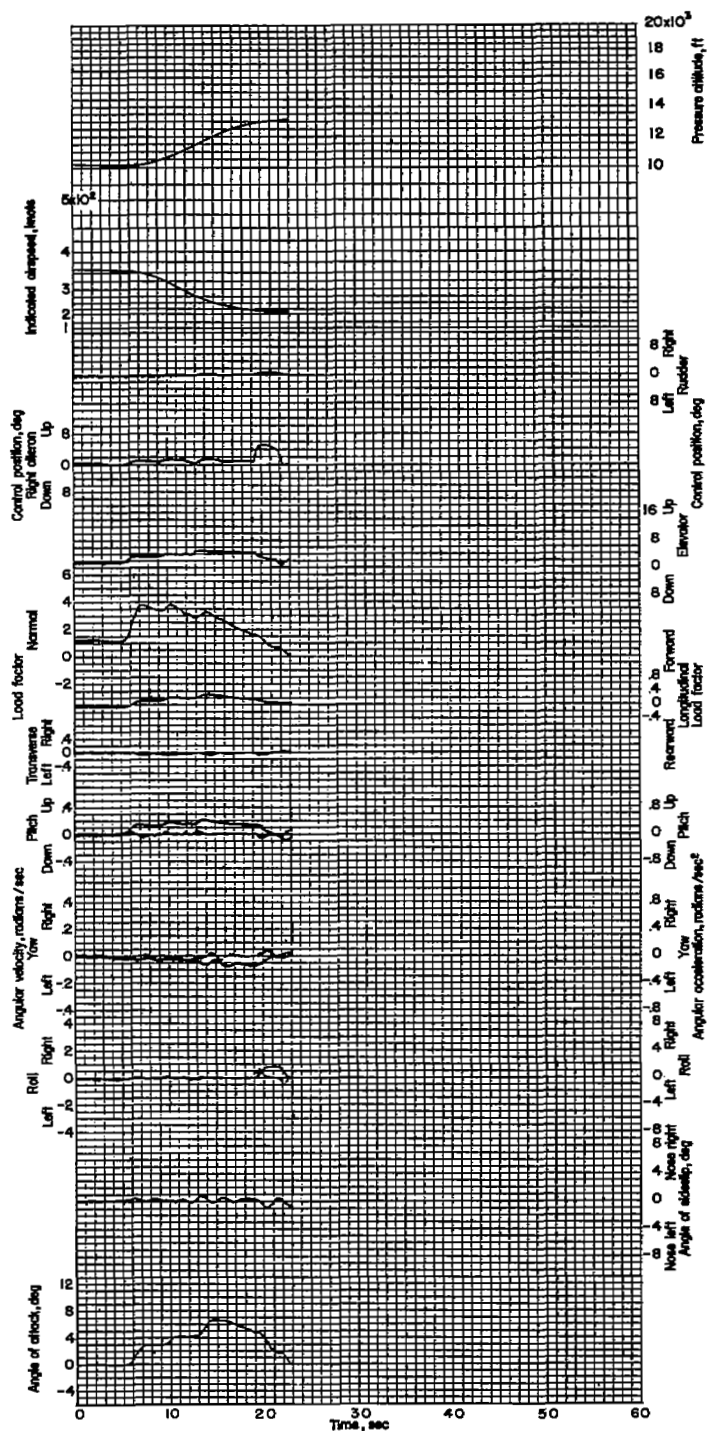


Figure 172.- Chandelle. Pilot A; airplane weight, 12,085 pounds; center of gravity at 27.1 percent M.A.C.

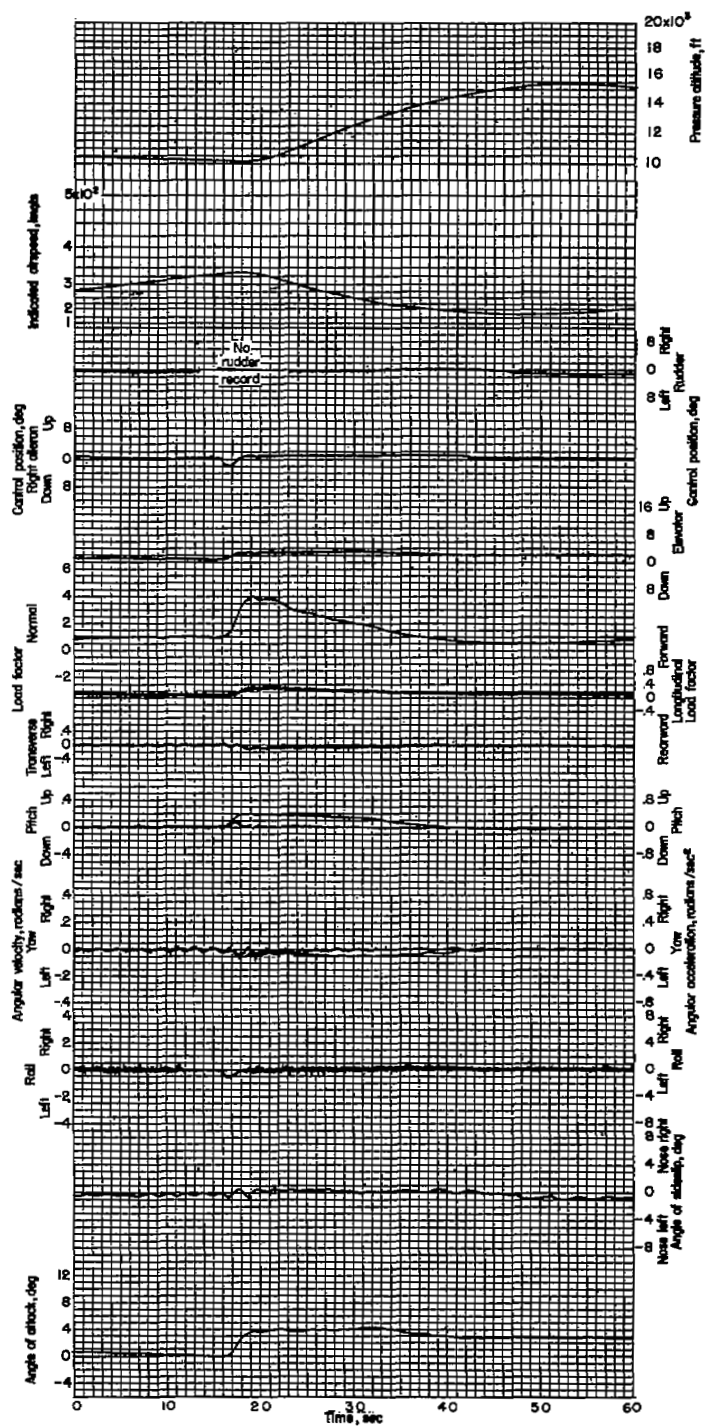


Figure 173.- Chandelle. Pilot A; airplane weight, 12,580 pounds; center of gravity at 27.7 percent M.A.C.



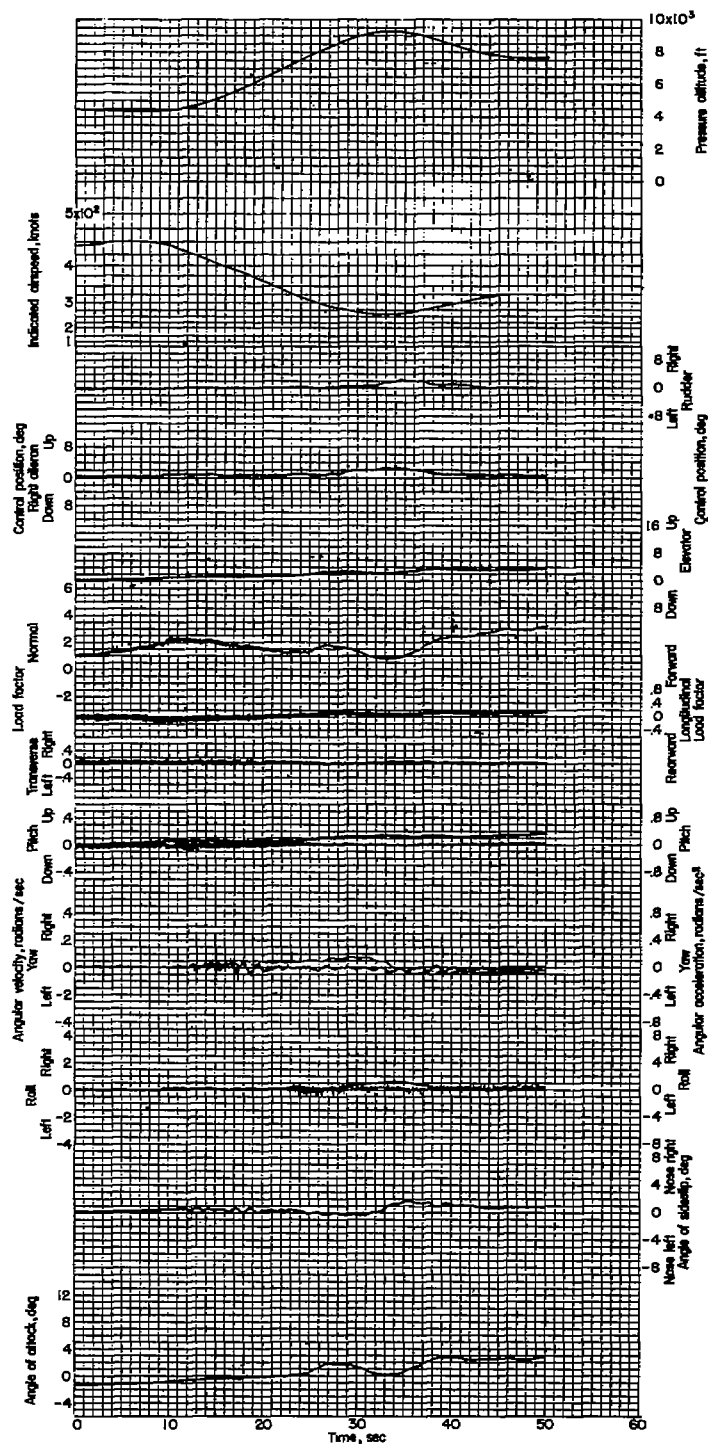


Figure 174.- Chandelle. Pilot A wearing anti-gravity suit; airplane weight, 11,810 pounds; center of gravity at 26.5 percent M.A.C.

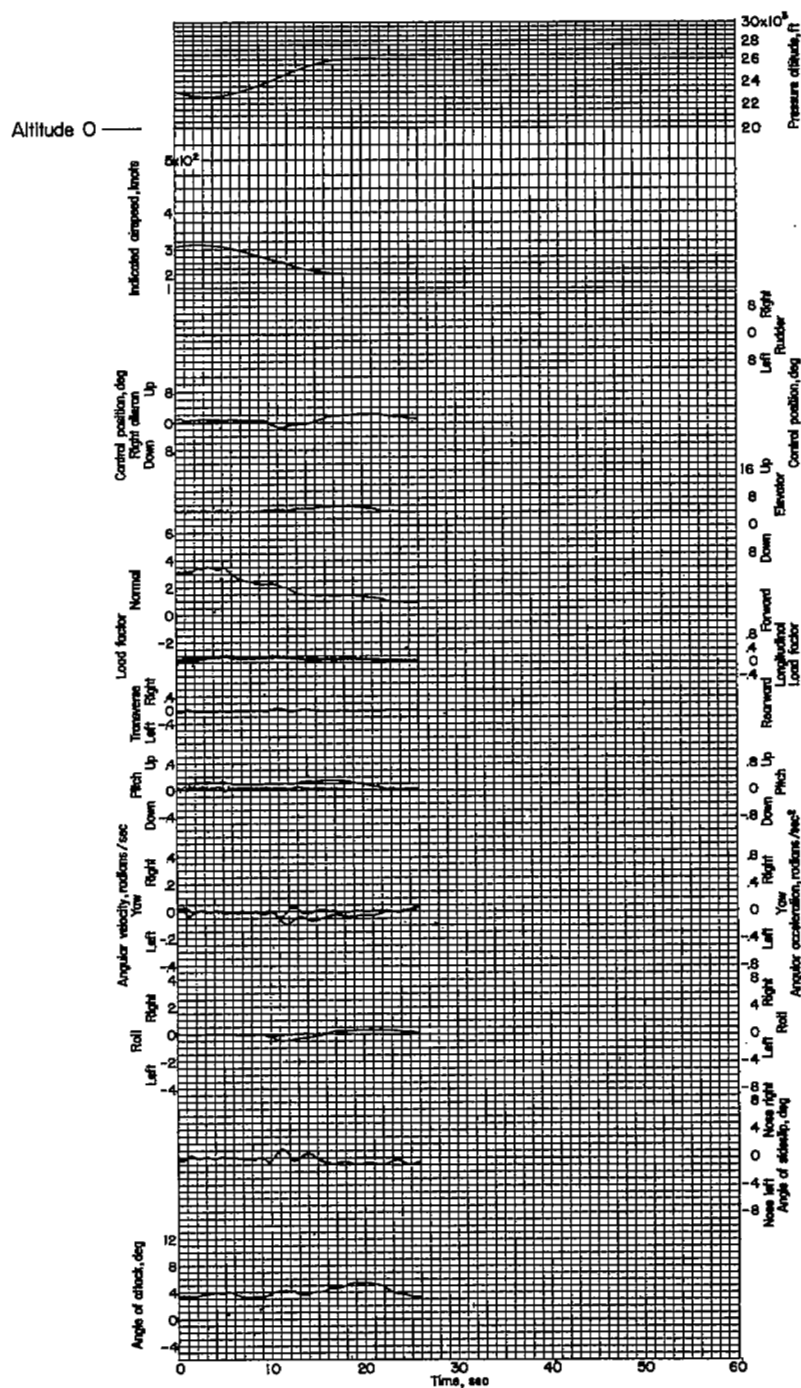


Figure 175.- Chandelle. Pilot B with radar observer; airplane weight, 12,149 pounds; center of gravity at 25.8 percent M.A.C.



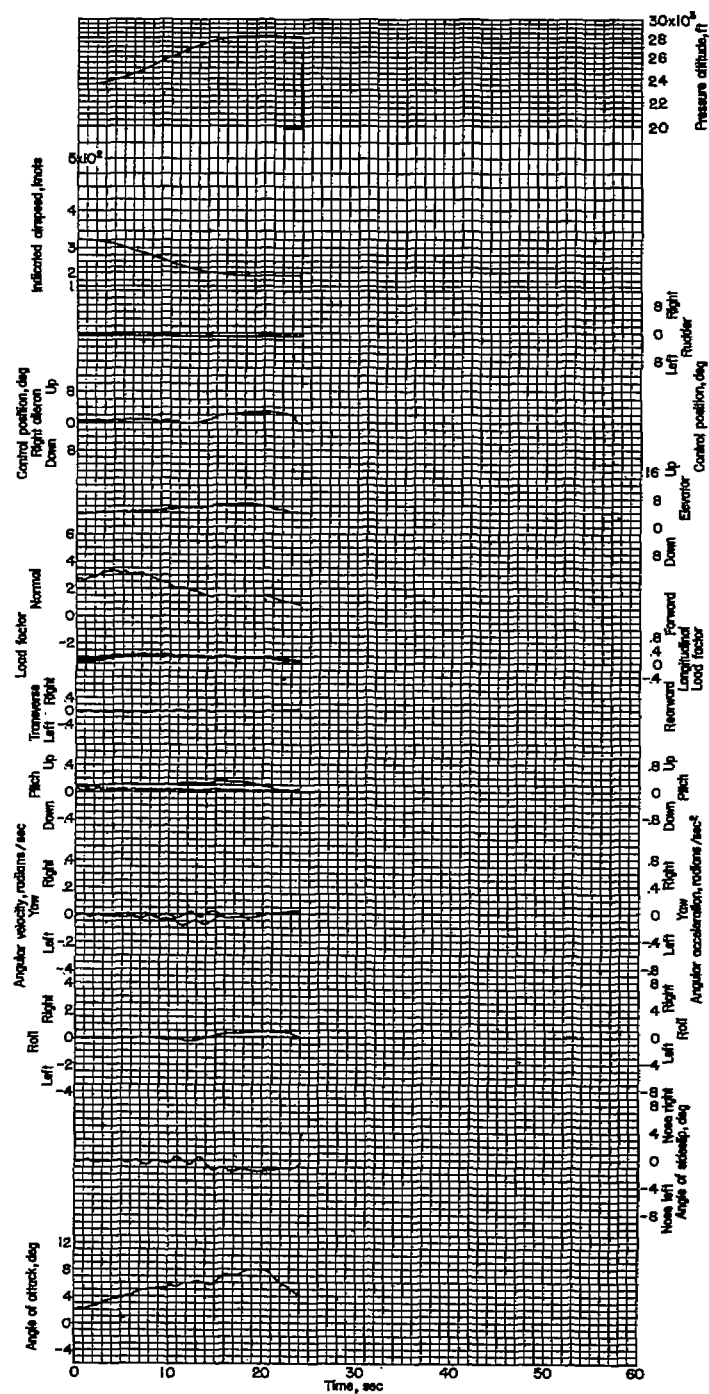


Figure 176.- Chandelle. Pilot B with radar observer; airplane weight, 12,195 pounds; center of gravity at 25.9 percent M.A.C.

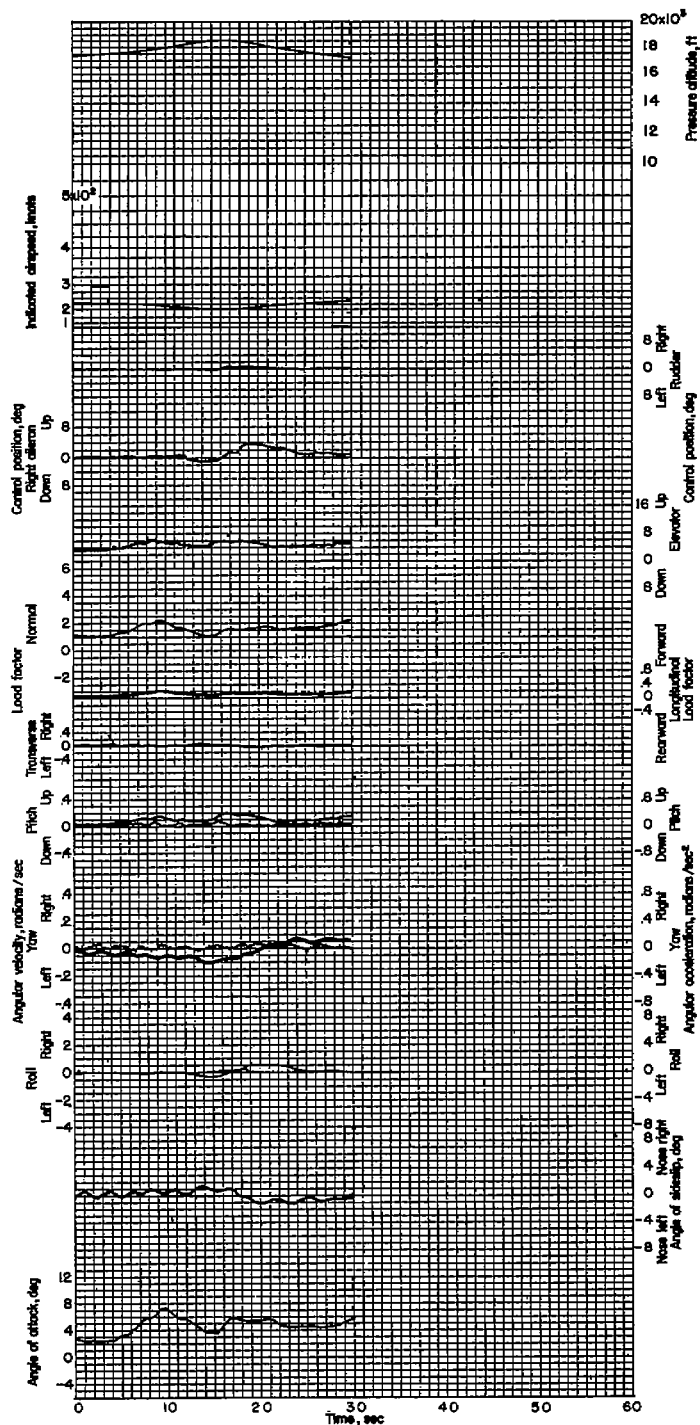
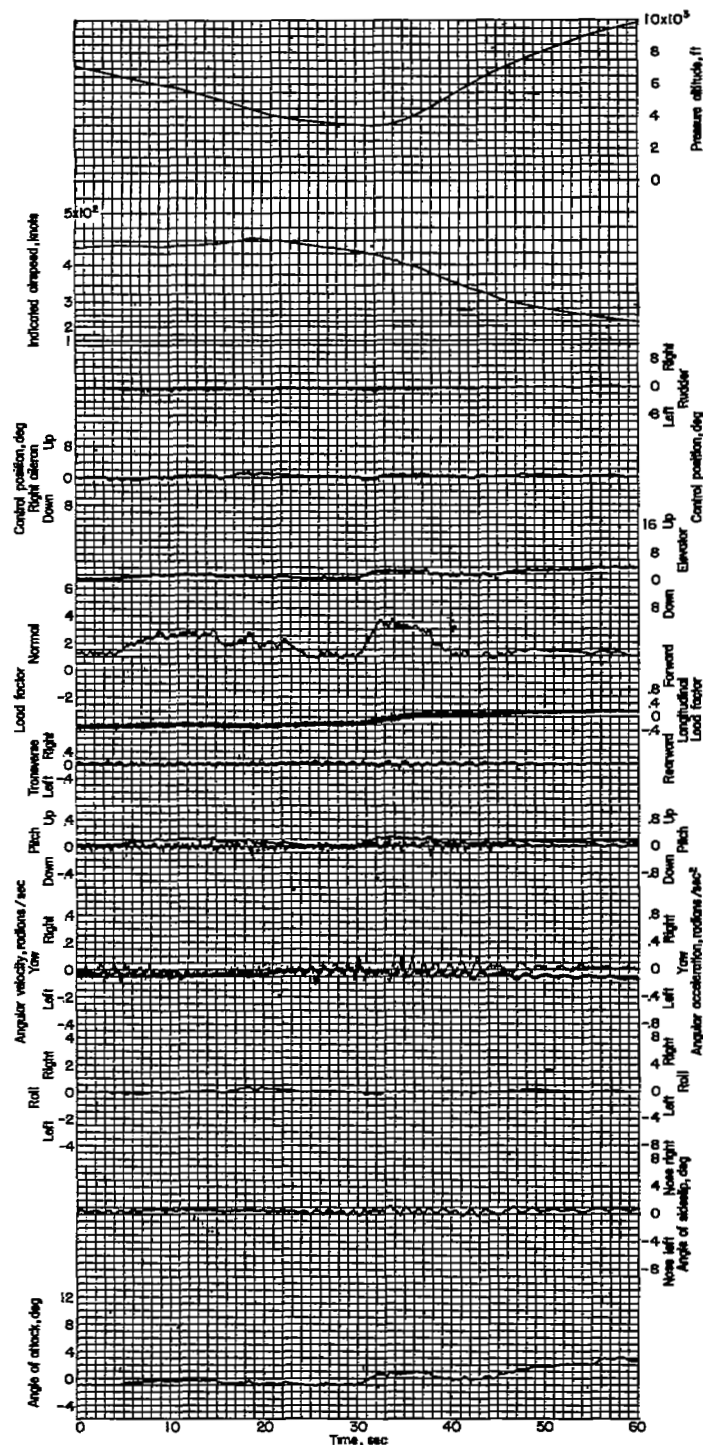


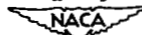
Figure 177.- Chandelle. Pilot C with radar observer; airplane weight, 12,225 pounds; center of gravity at 26.0 percent M.A.C.

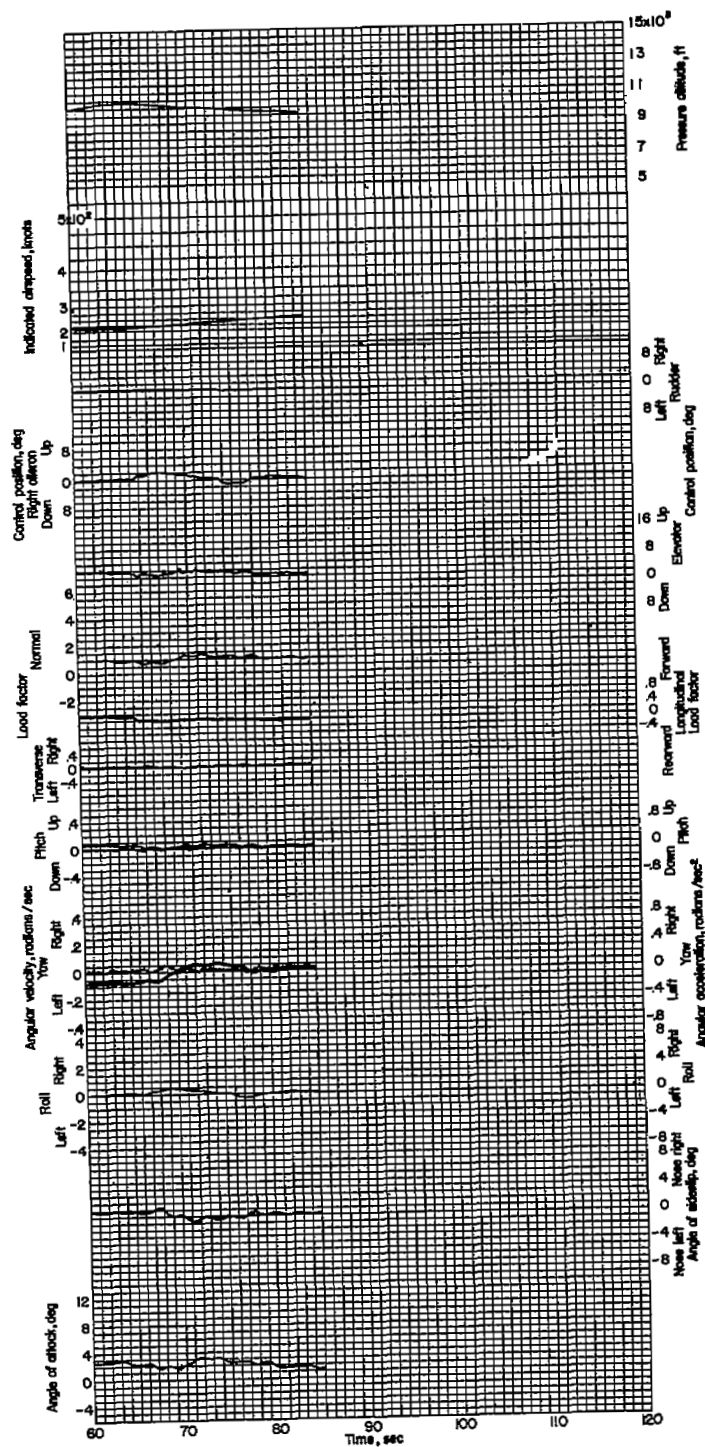
NACA



(a)

Figure 178.- Chandelle. Pilot C with radar observer; airplane weight, 11,970 pounds; center of gravity at 25.5 percent M.A.C.





(b)



Figure 178.- Concluded.

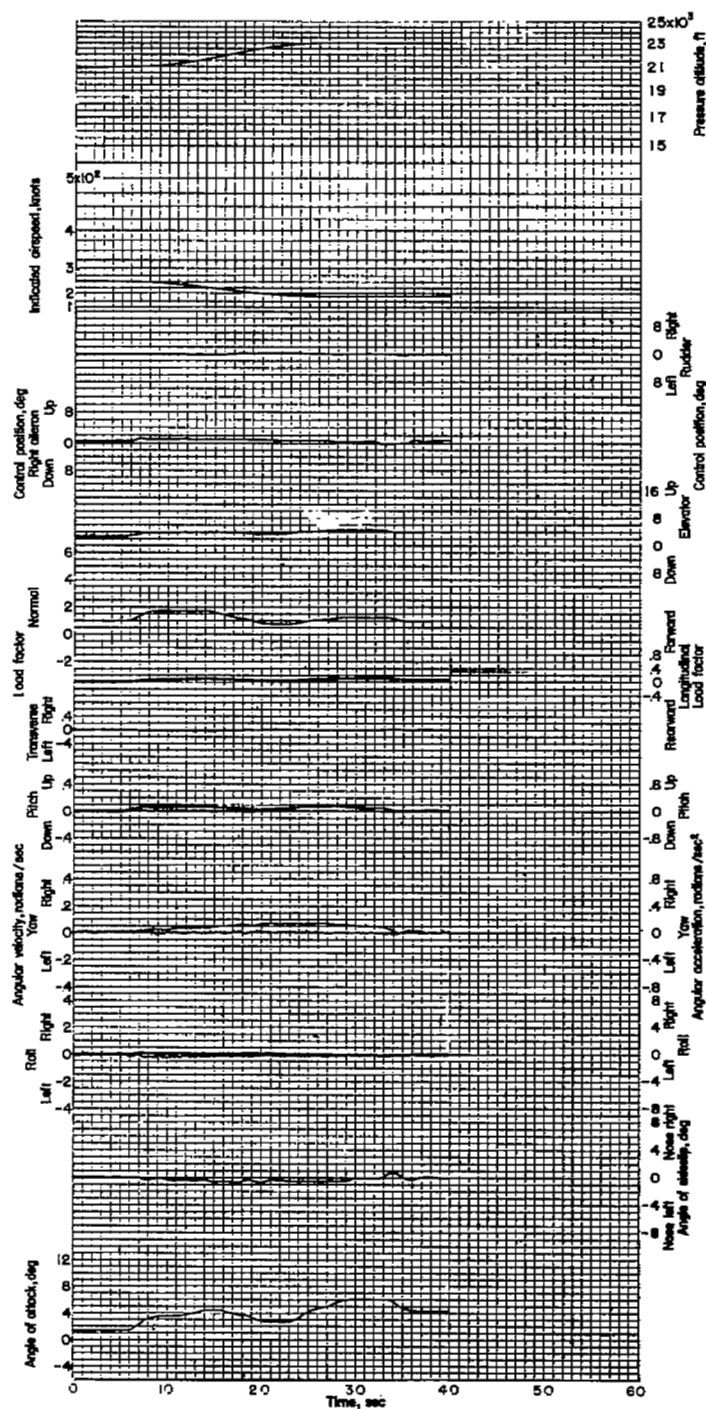


Figure 179.- Chandelle. Pilot E wearing anti-gravity suit; airplane weight, 12,060 pounds; center of gravity at 27.0 percent M.A.C.

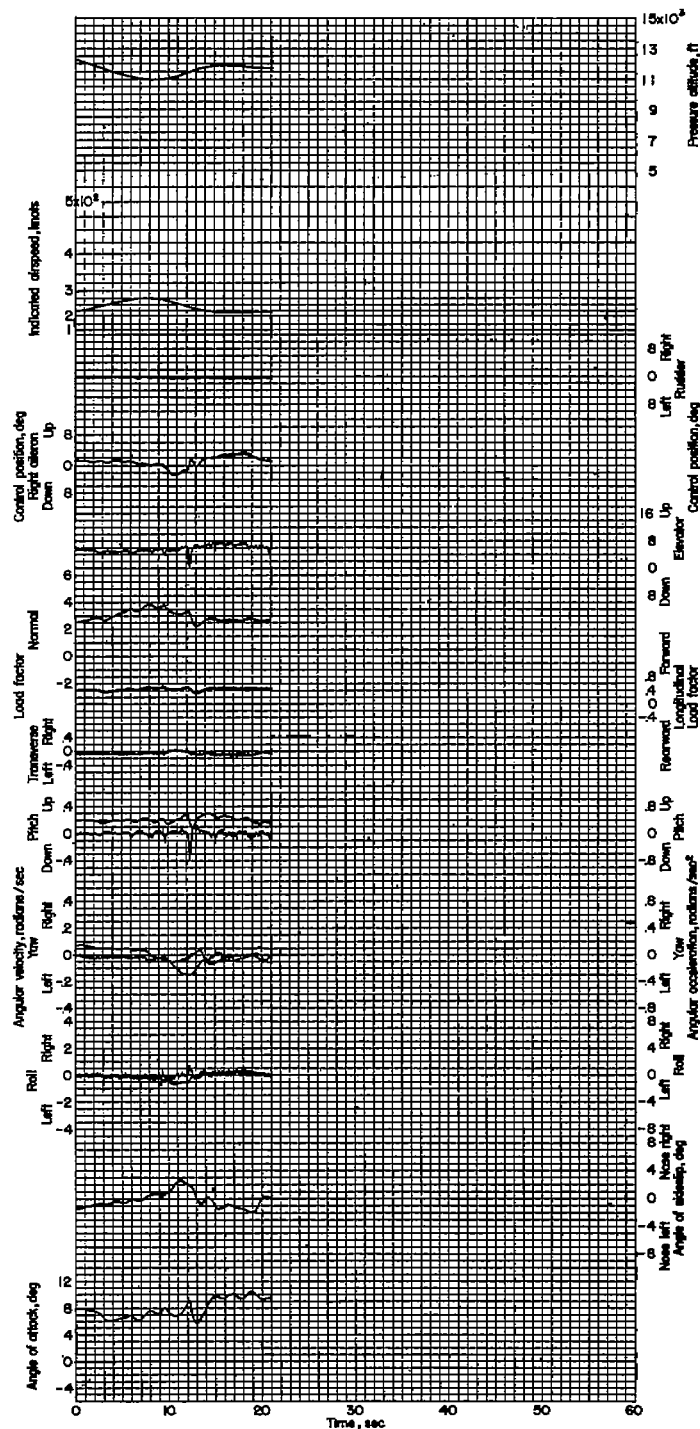


Figure 180.- Chandelle. Pilot F wearing anti-gravity suit; airplane weight, 12,350 pounds; center of gravity at 27.6 percent M.A.C.

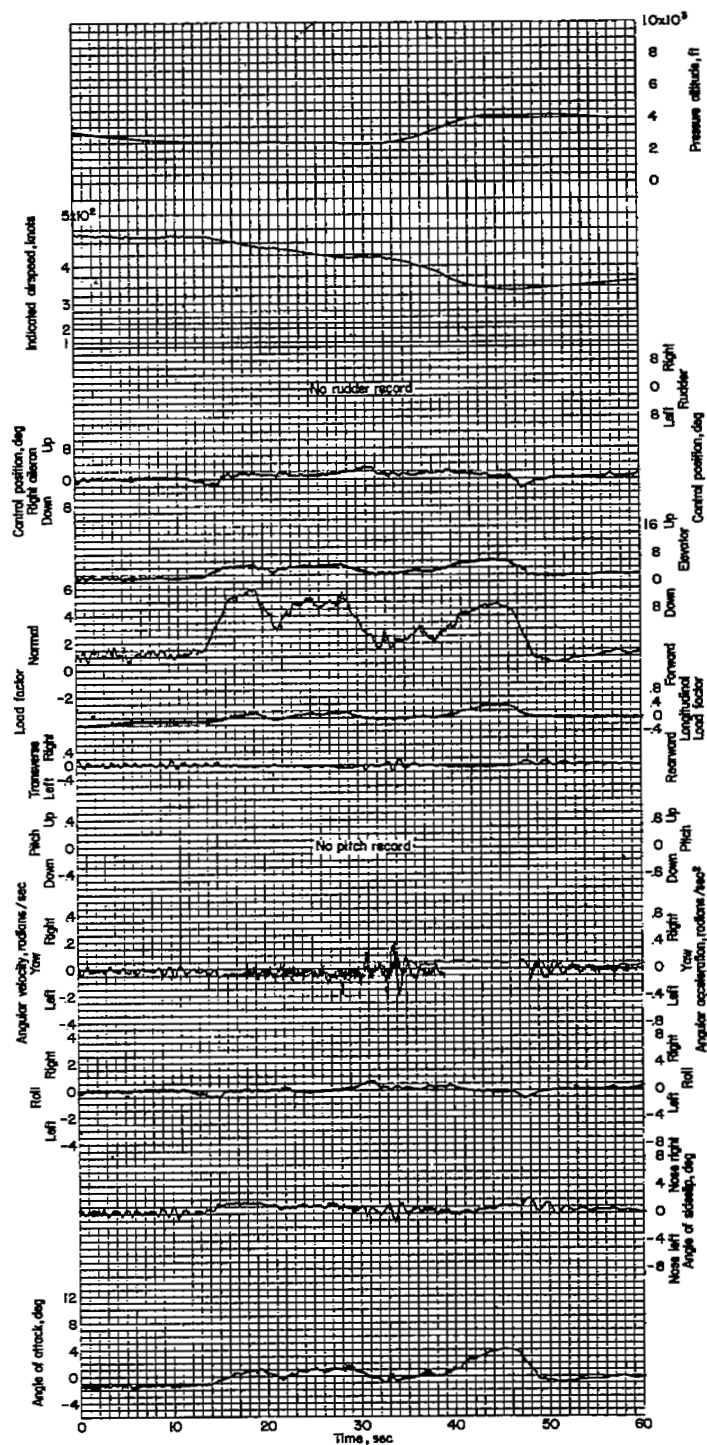


Figure 181.- Chandelle. Pilot G with radar observer; airplane weight, 12,250 pounds; center of gravity at 26.0 percent M.A.C.

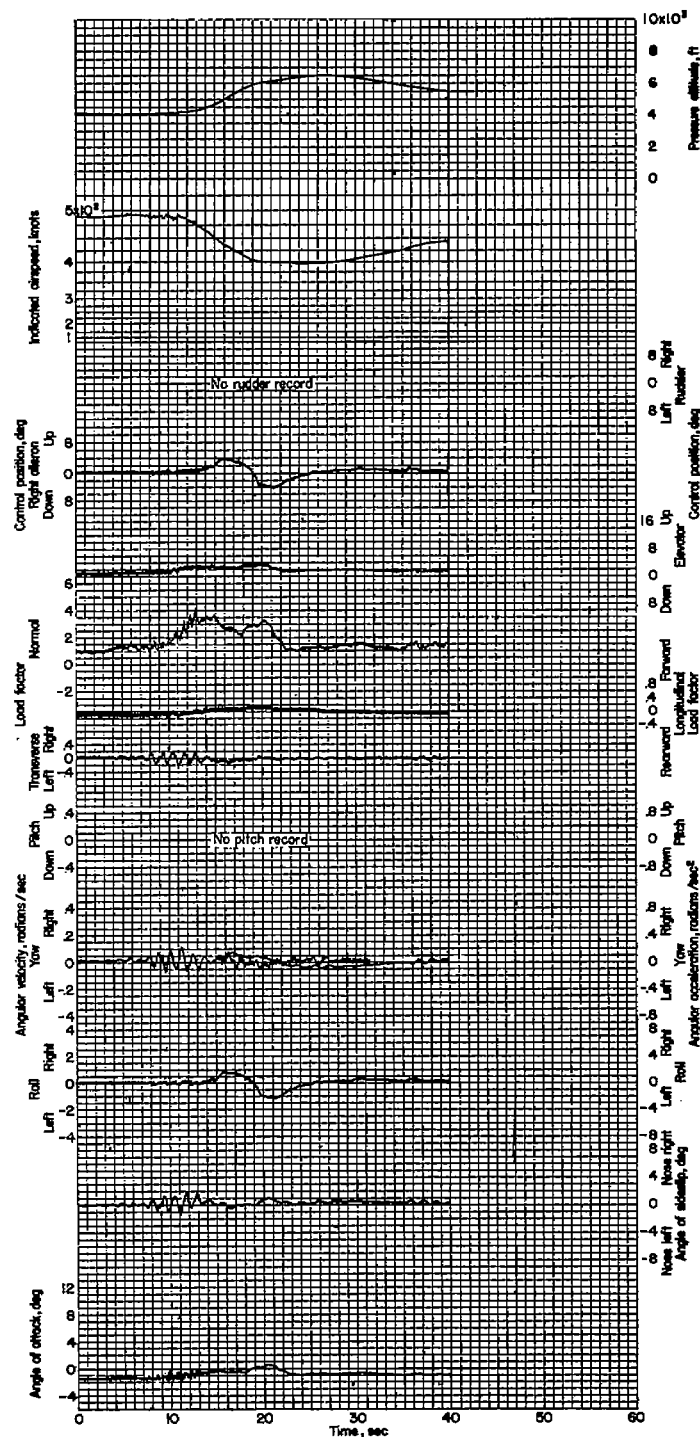


Figure 182.- Chandelle. Pilot G with radar observer; airplane weight, 12,380 pounds; center of gravity at 26.3 percent M.A.C.

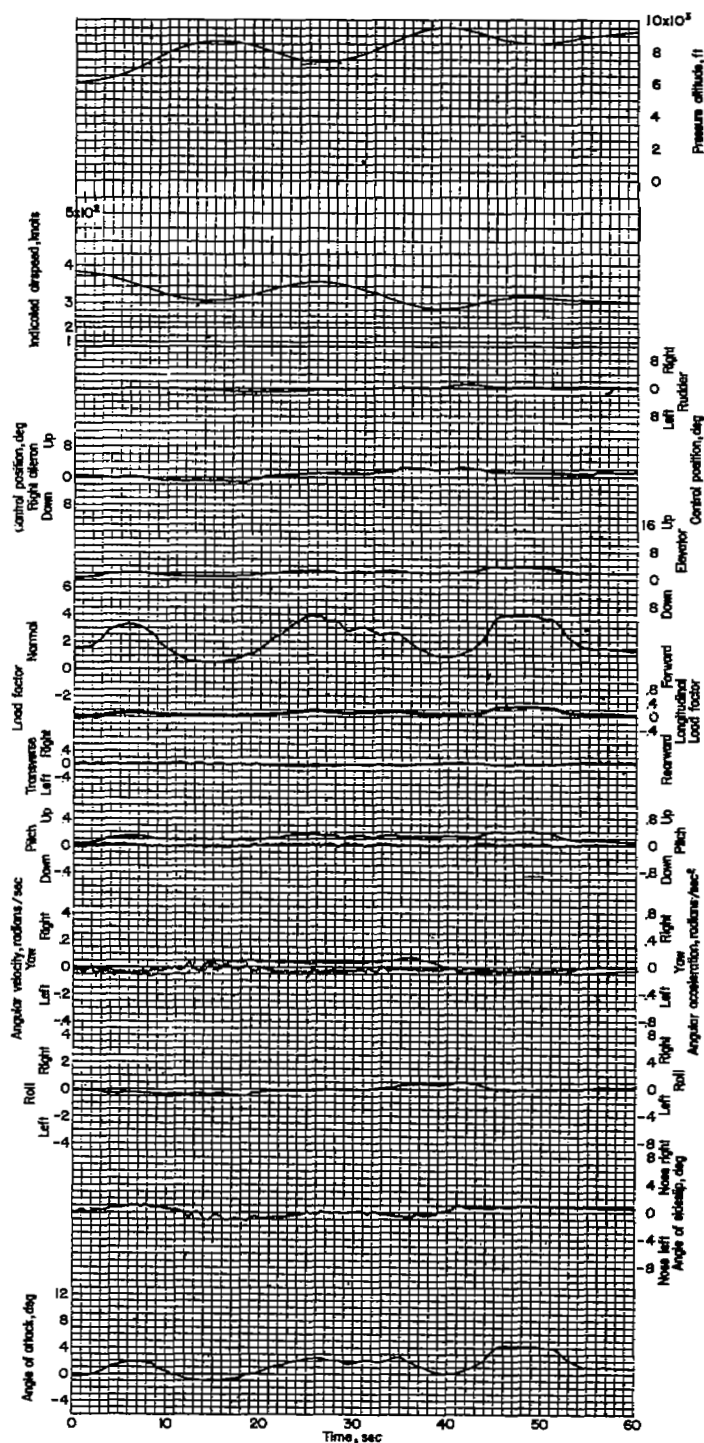
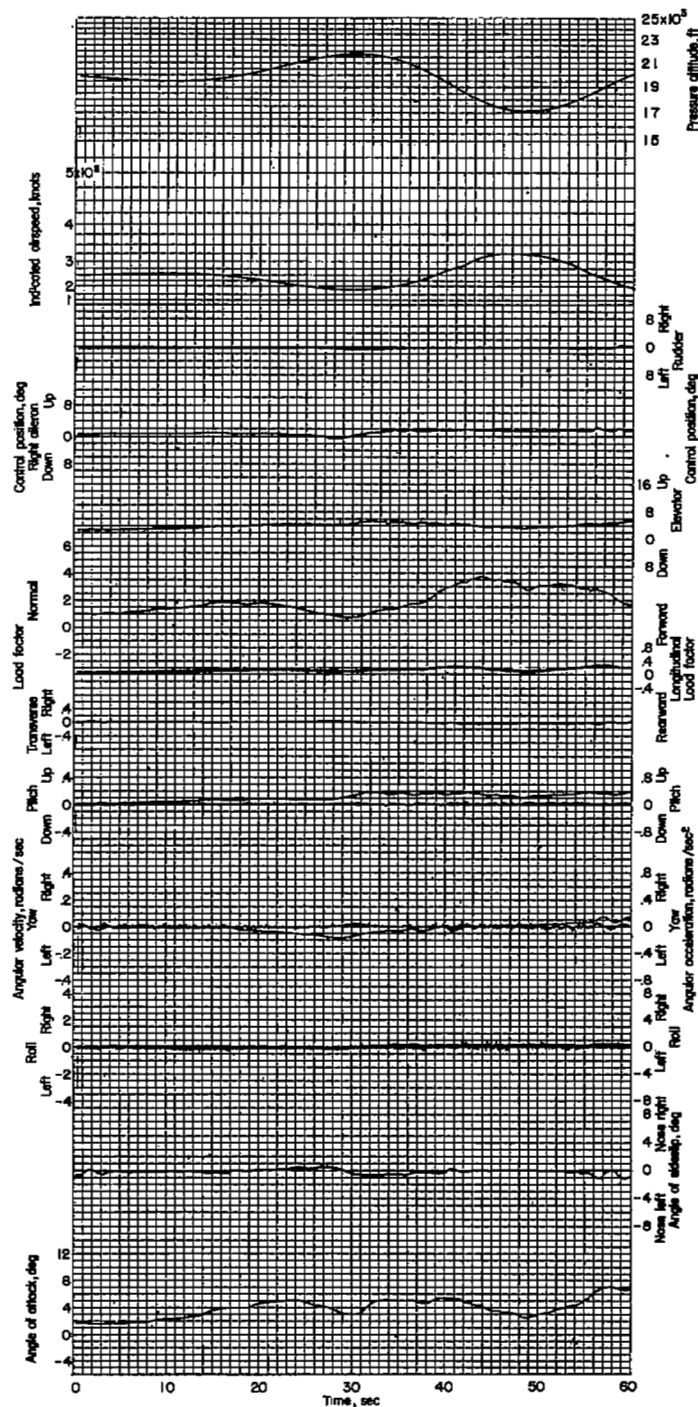


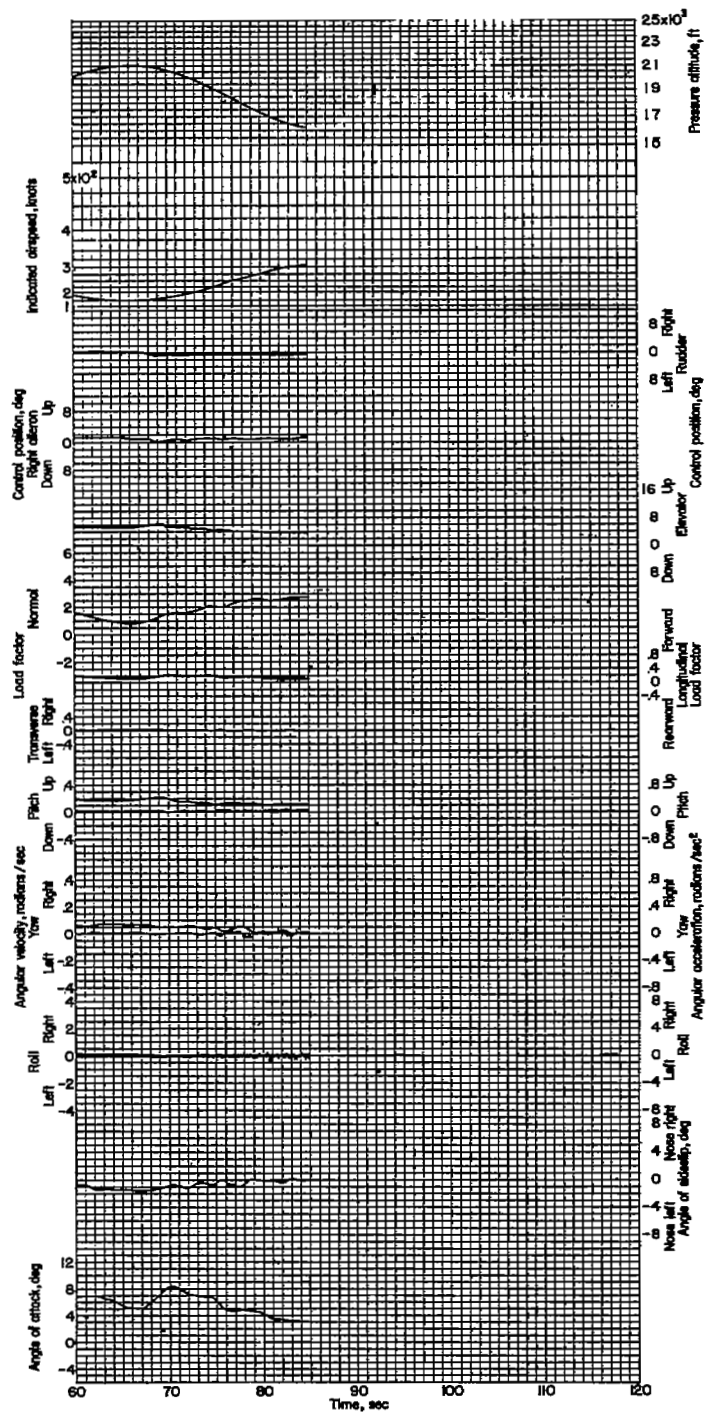
Figure 183.- Lazy eight. Pilot A wearing anti-gravity suit; airplane weight, 12,405 pounds; center of gravity at 27.6 percent M.A.C.



(a)



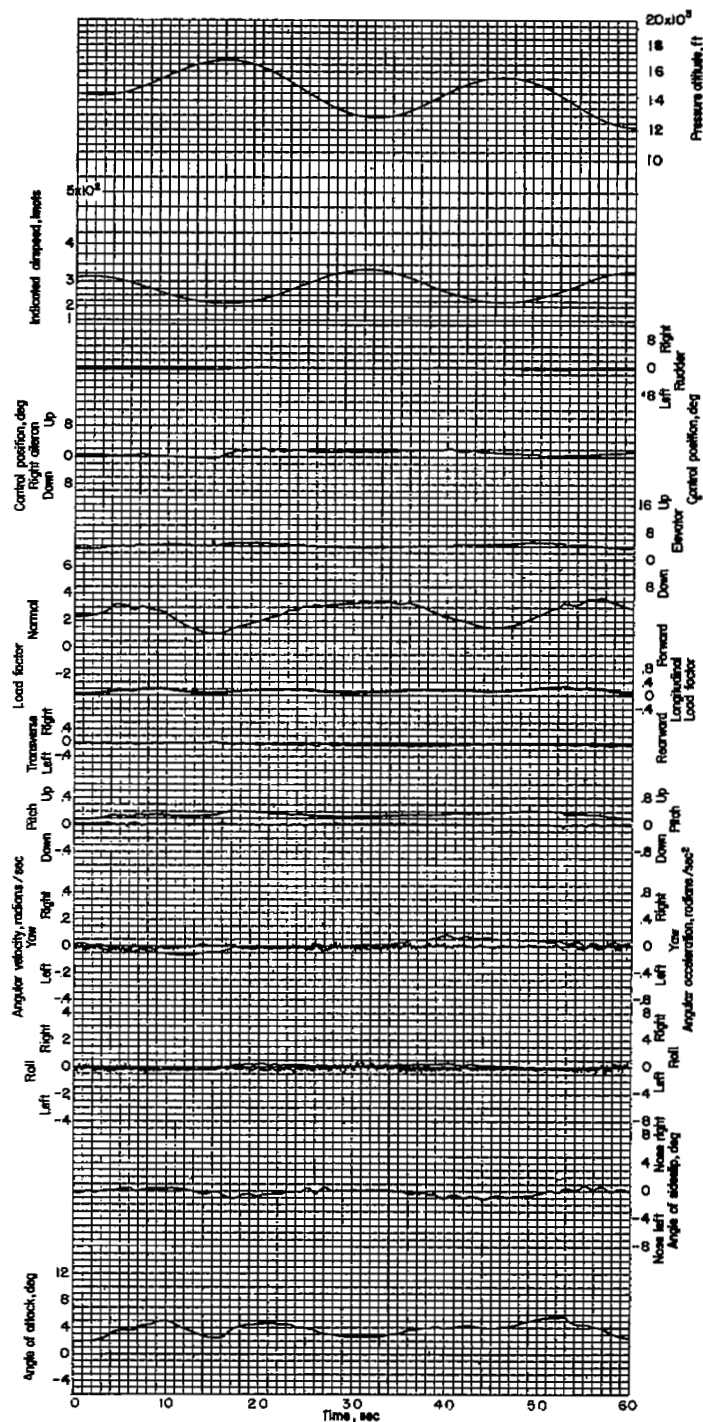
Figure 184.- Lazy eight. Pilot E wearing anti-gravity suit; airplane weight, 11,880 pounds; center of gravity at 26.7 percent M.A.C.



(b)

Figure 184.- Concluded.





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Figure 185.- Lazy eight. Pilot E wearing anti-gravity suit; airplane weight, 11,710 pounds; center of gravity at 26.4 percent M.A.C.

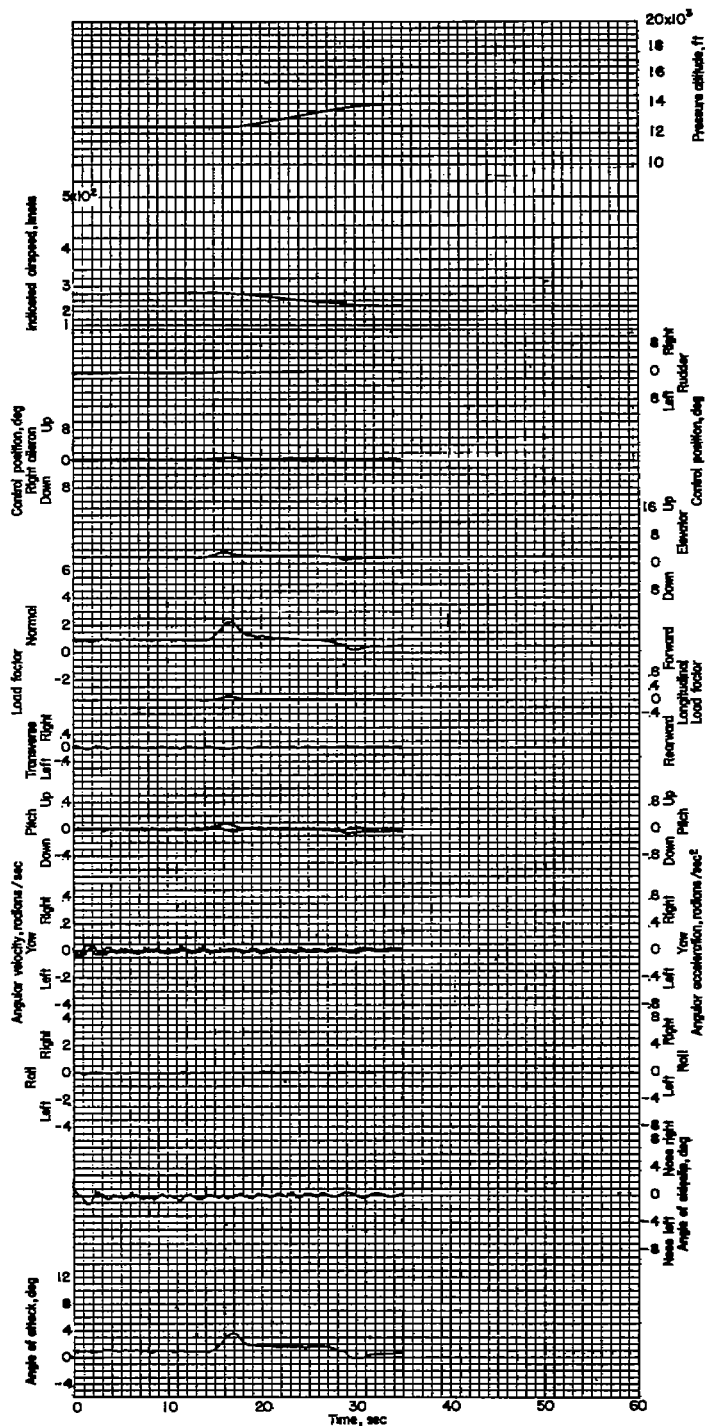


Figure 186.- Pull-up. Pilot A; airplane weight, 12,125 pounds; center of gravity at 27.2 percent M.A.C.

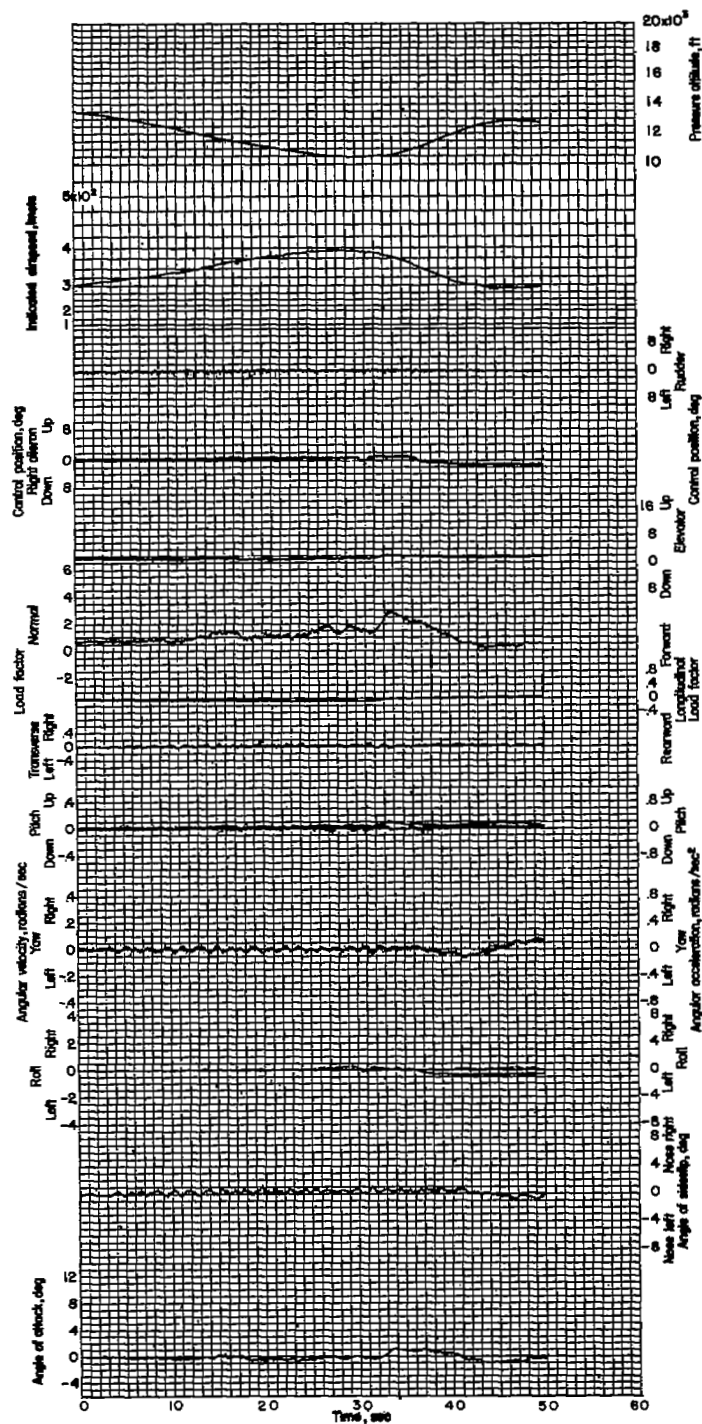


Figure 187.- Pull-up. Pilot A; airplane weight, 12,170 pounds; center of gravity at 27.2 percent M.A.C.

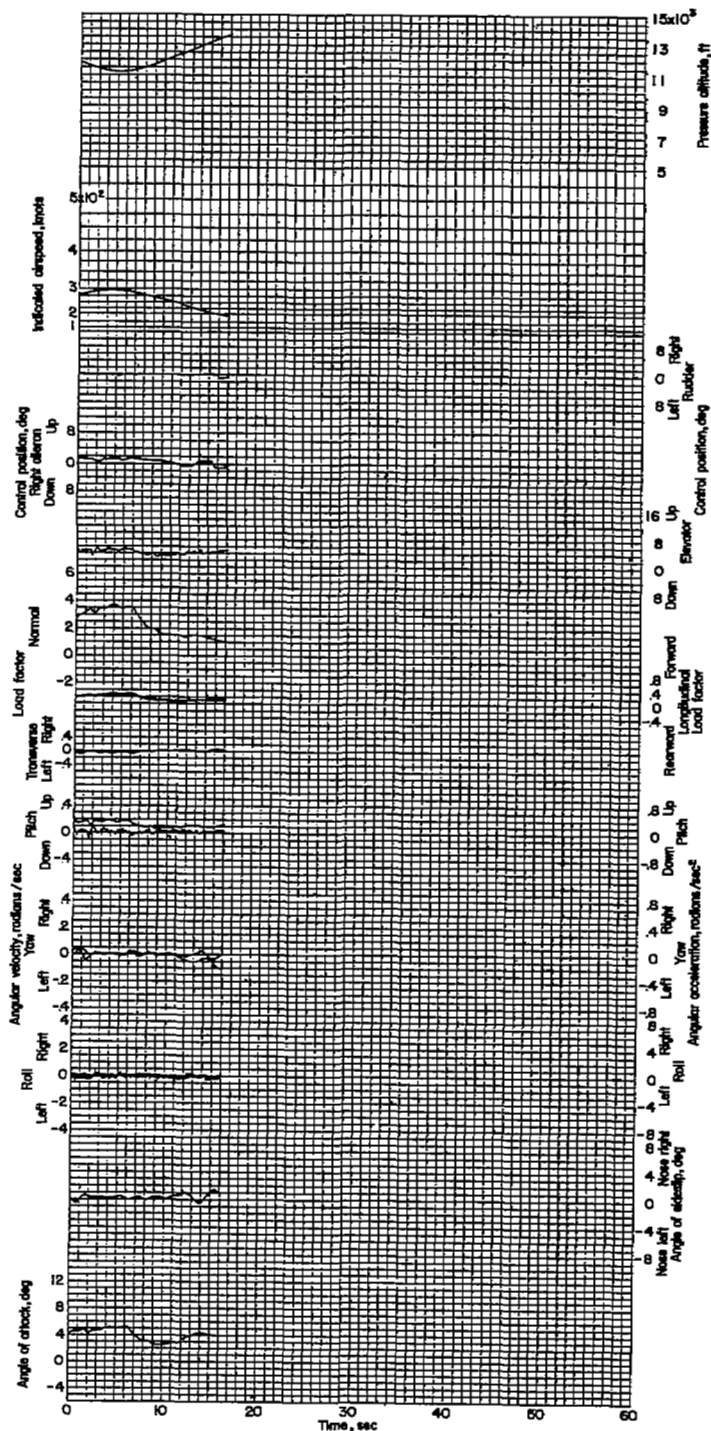


Figure 188.- Pull-up. Pilot B; airplane weight, 11,950 pounds; center of gravity at 26.8 percent M.A.C.

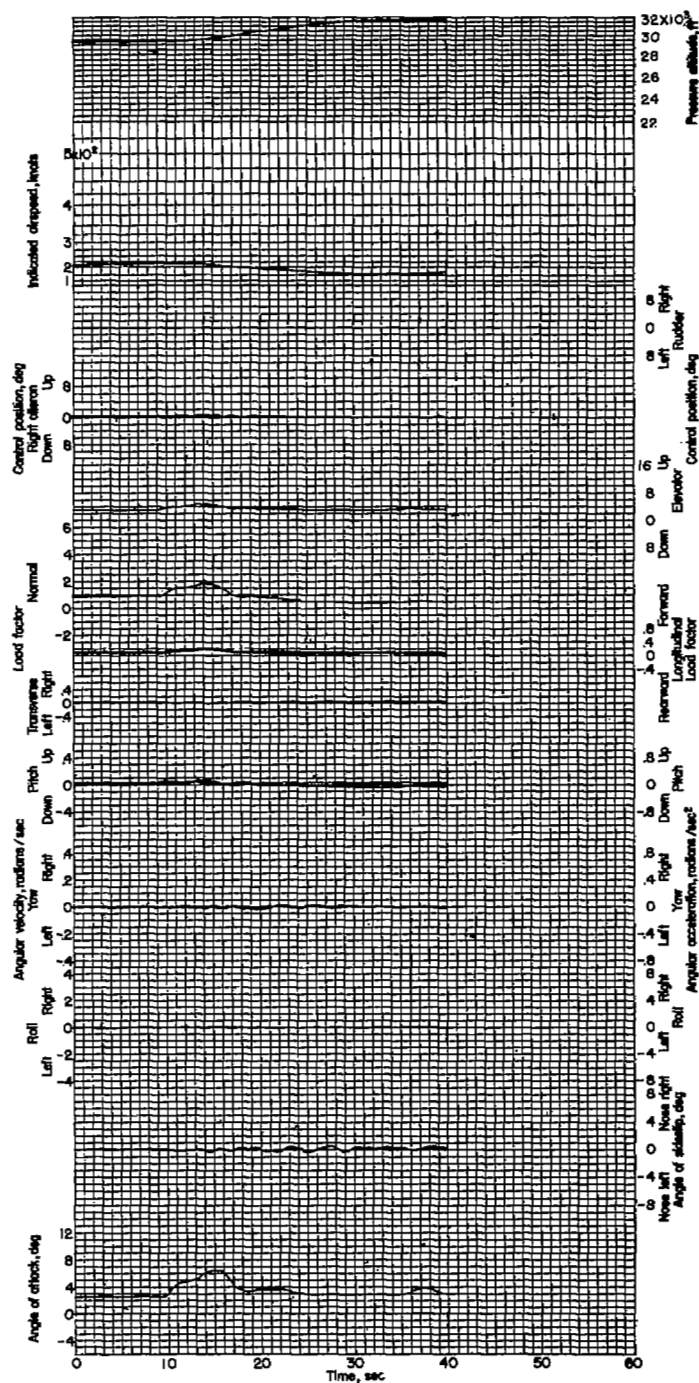
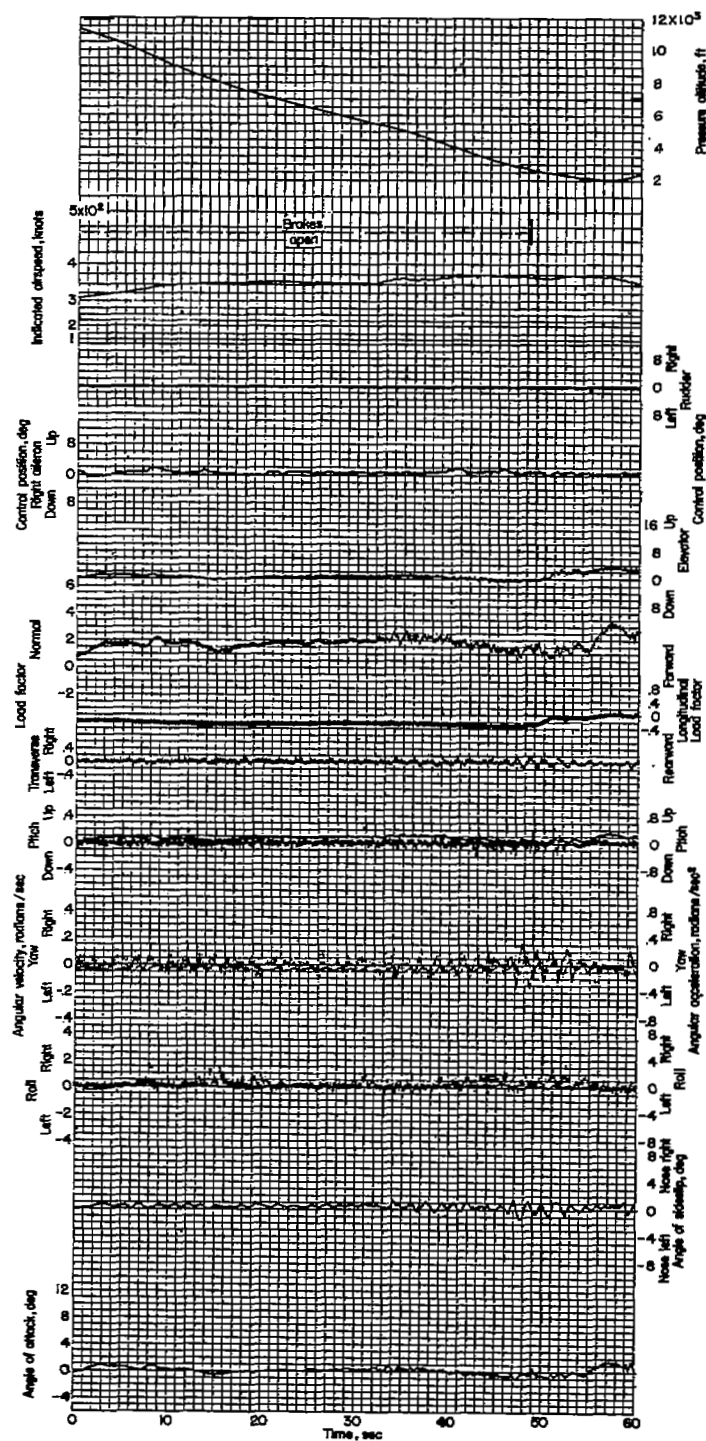


Figure 189.- Pull-up. Pilot B with radar observer; airplane weight, 12,300 pounds; center of gravity at 26.2 percent M.A.C.

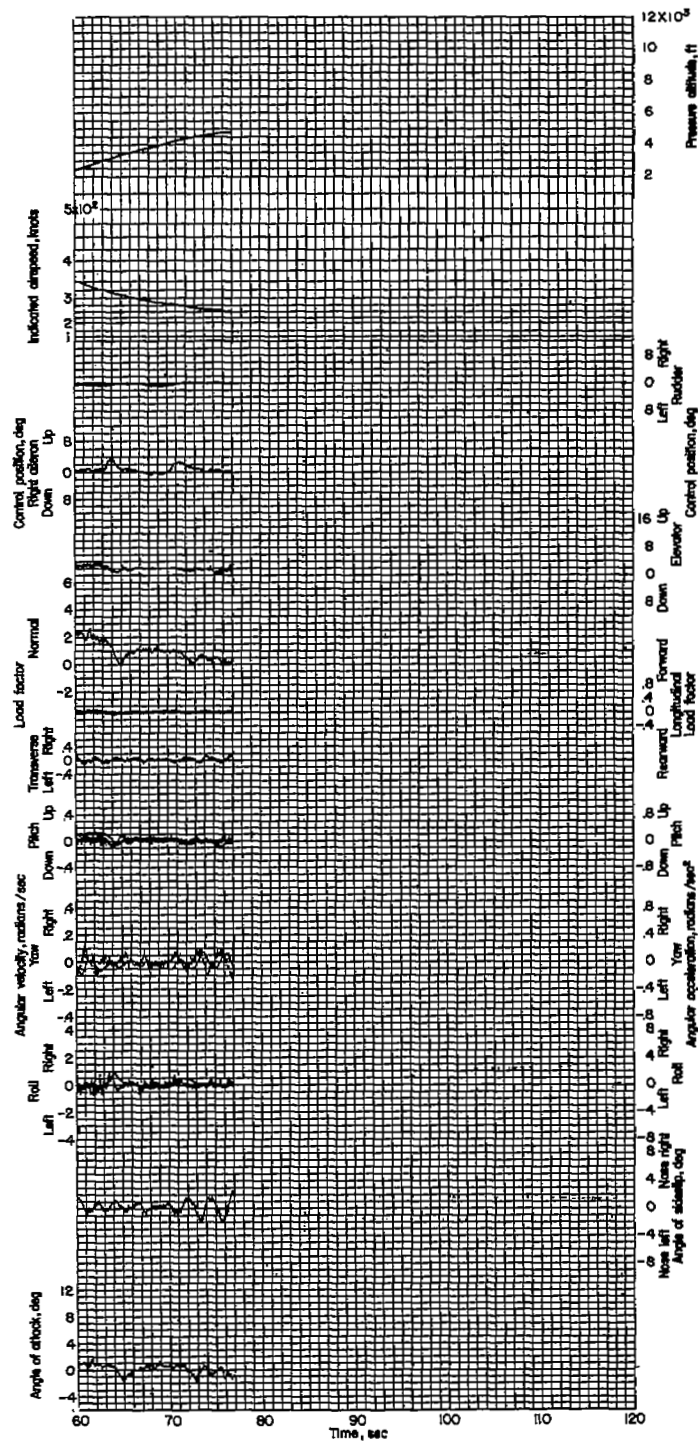
NACA



(a)



Figure 190.- Pull-up. Pilot E wearing anti-gravity suit; airplane weight, 11,640 pounds; center of gravity at 26.2 percent M.A.C.



(b)



Figure 190.- Concluded.

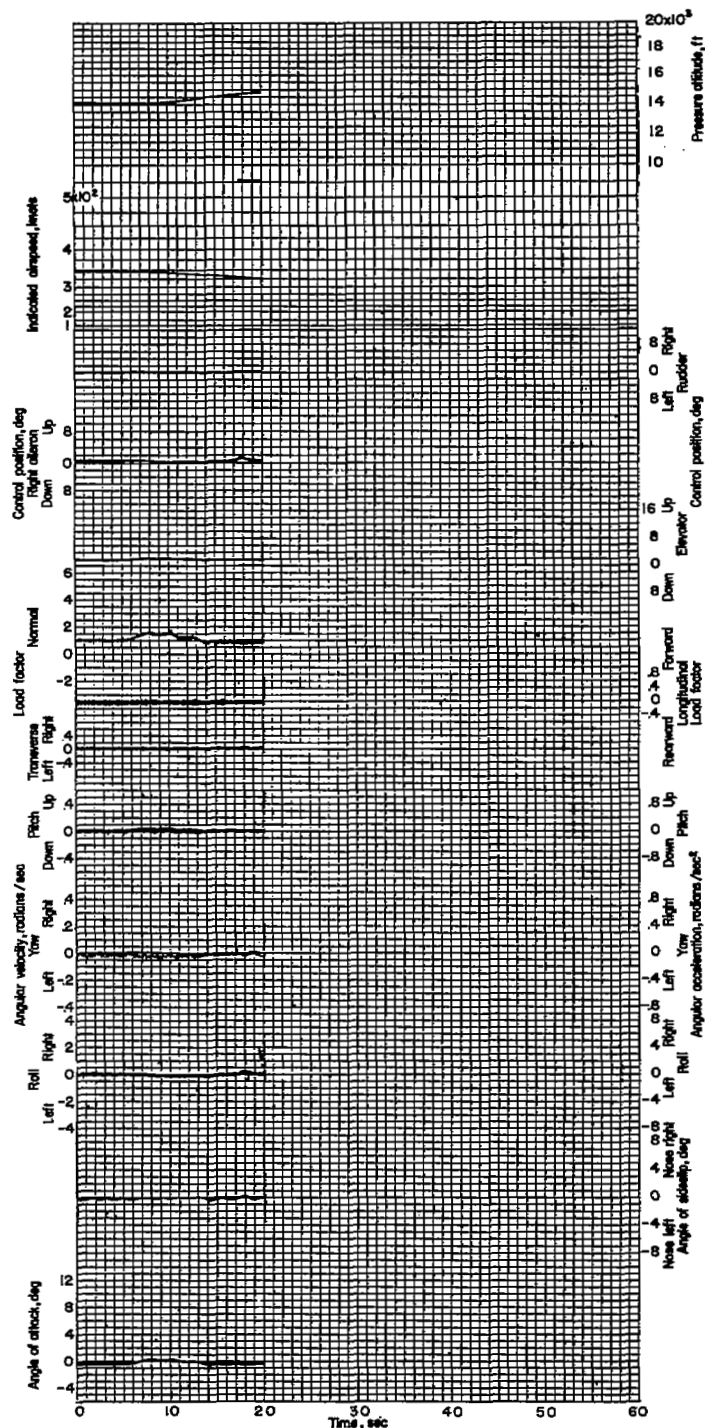


Figure 191.- Pull-up. Pilot F wearing anti-gravity suit and with radar observer; airplane weight, 12,440 pounds; center of gravity at 26.4 per cent M.A.C.

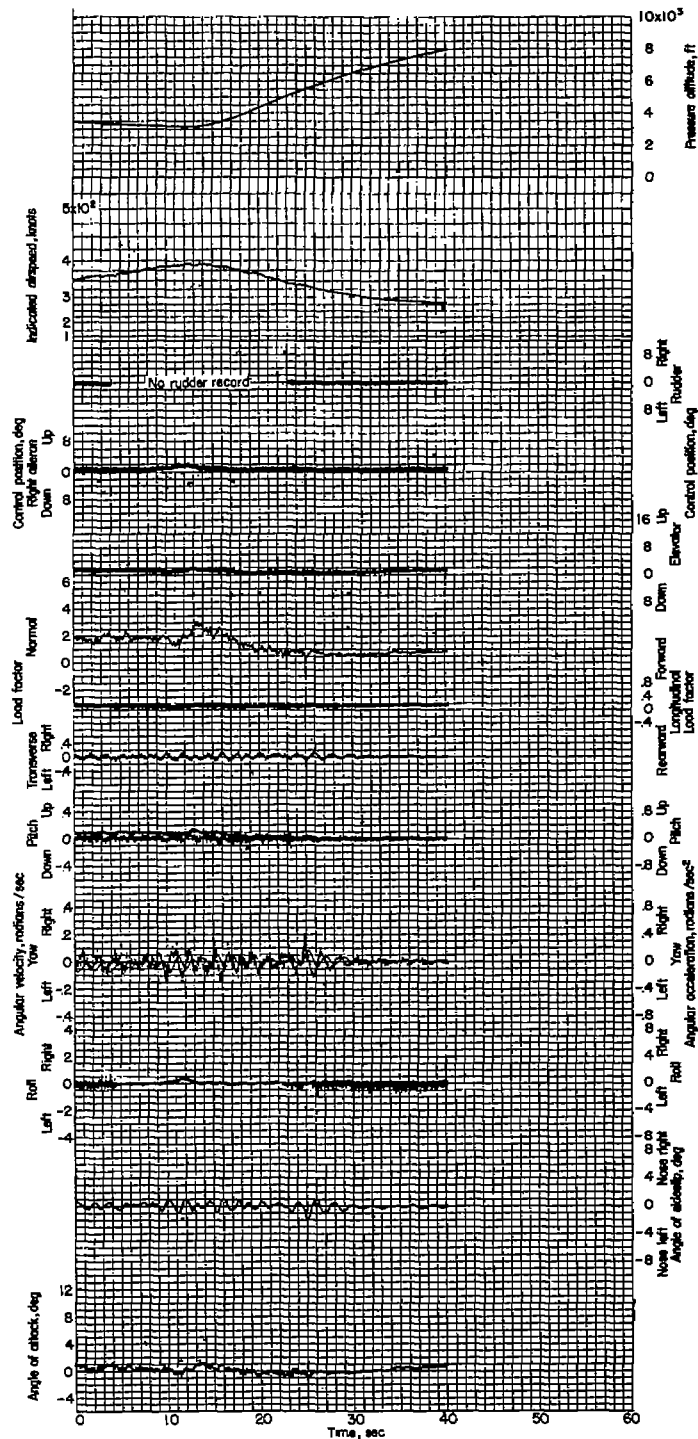


Figure 192.- Pull-up. Pilot F wearing anti-gravity suit and with radar observer; airplane weight, 12,840 pounds; center of gravity at 26.9 per-cent M.A.C.

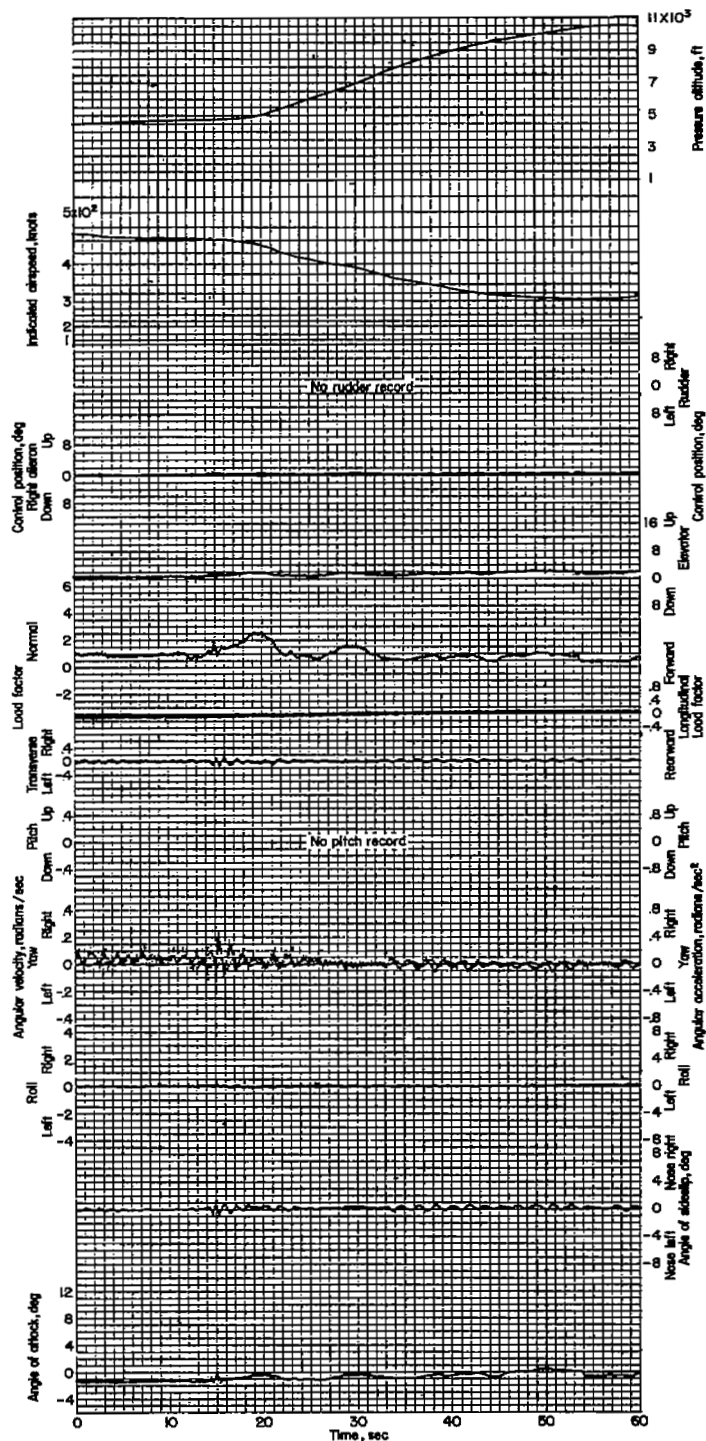


Figure 193.- Pull-up. Pilot G with radar observer; airplane weight, 12,910 pounds; center of gravity at 26.9 percent M.A.C.

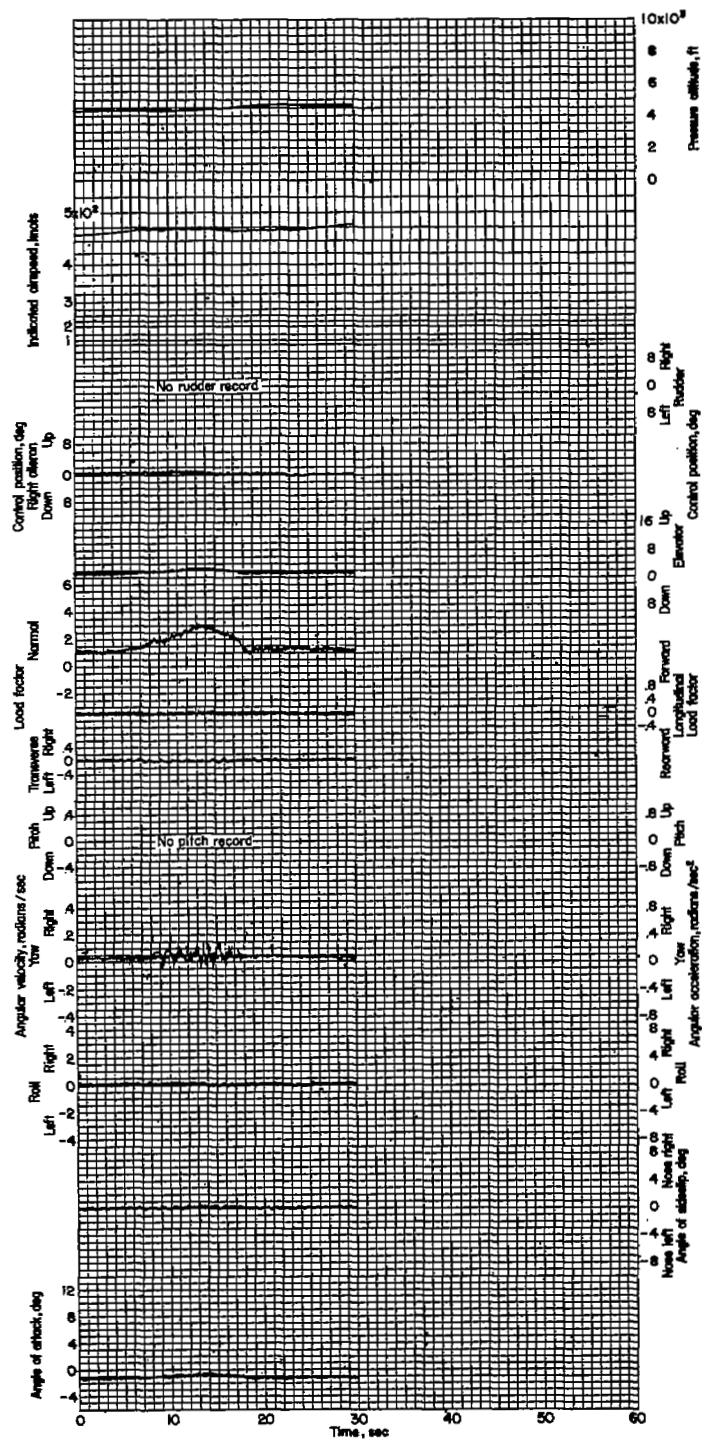


Figure 194.- Pull-up. Pilot G with radar observer; airplane weight, 12,350 pounds; center of gravity at 26.3 percent M.A.C.

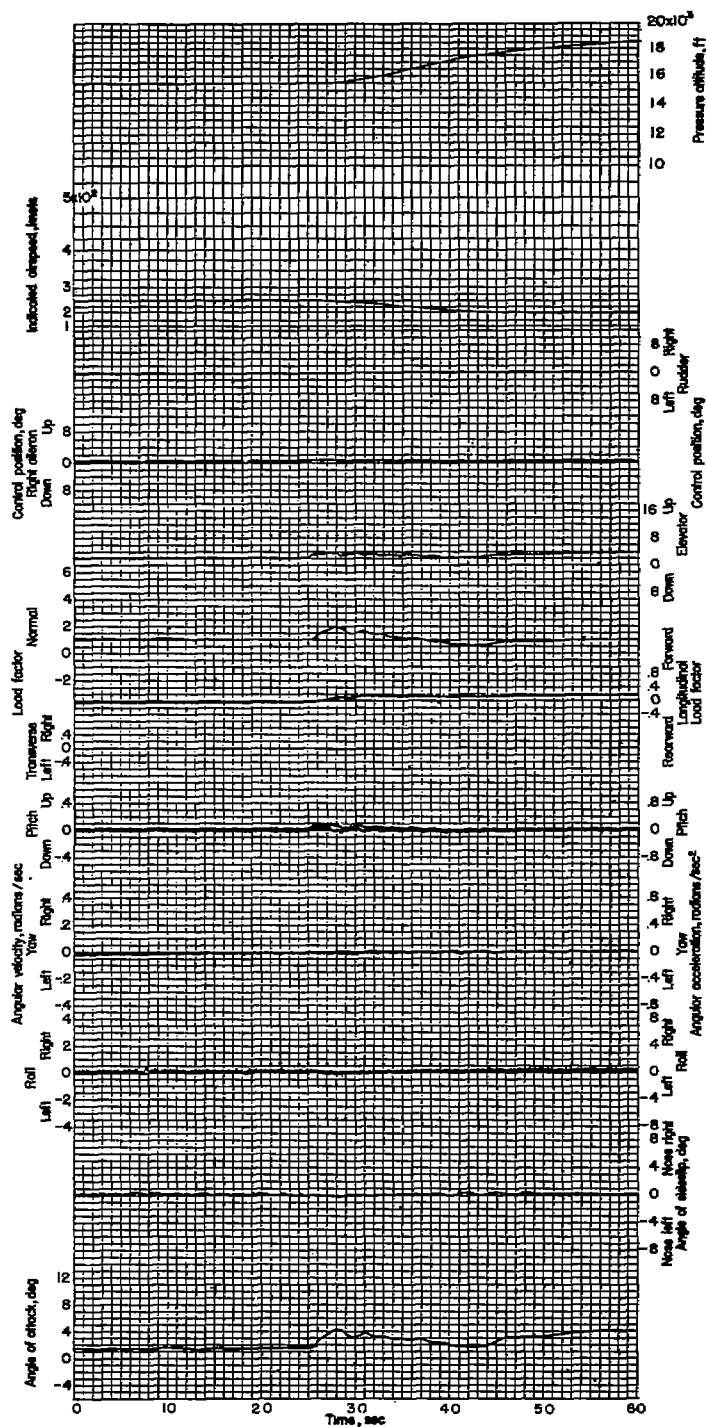


Figure 195.- Pull-up. Pilot H with radar observer; airplane weight, 12,050 pounds; center of gravity at 25.6 percent M.A.C.

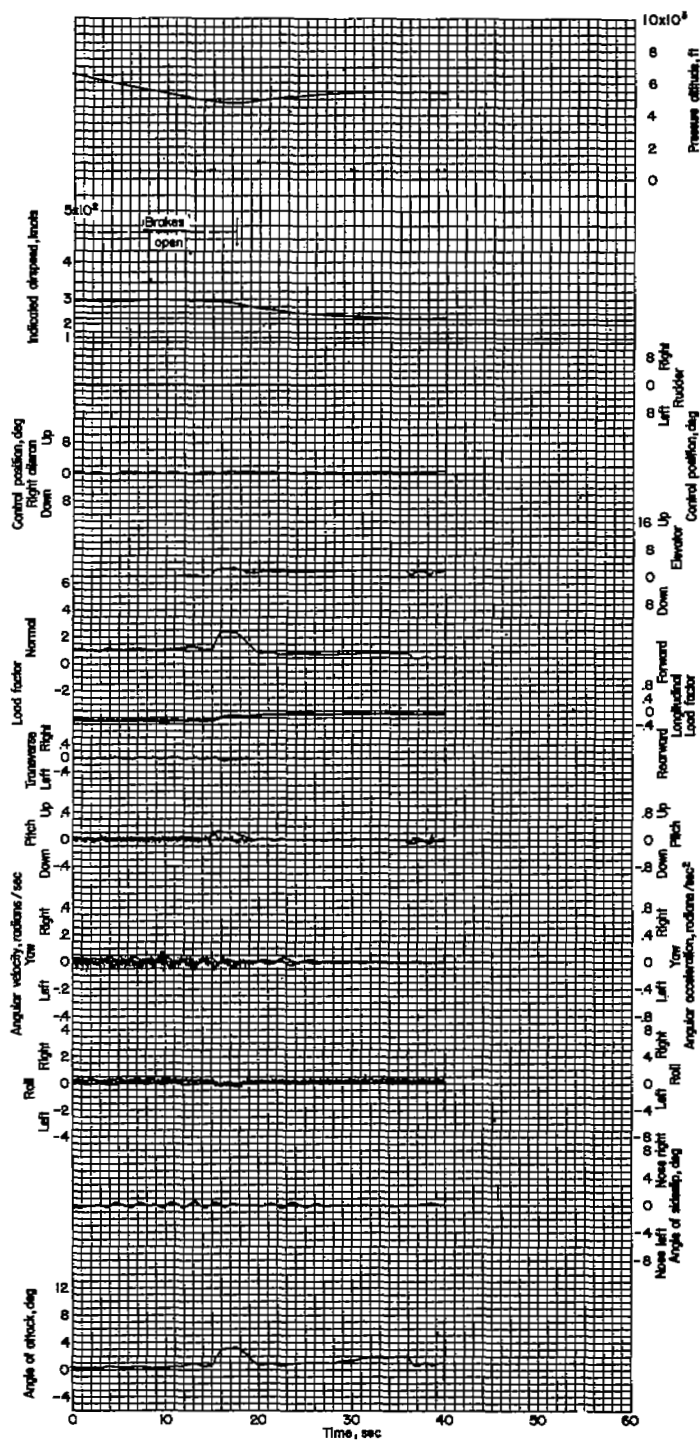


Figure 196.- Pull-up. Pilot H with radar observer; airplane weight. 12,850 pounds; center of gravity at 26.9 percent M.A.C.



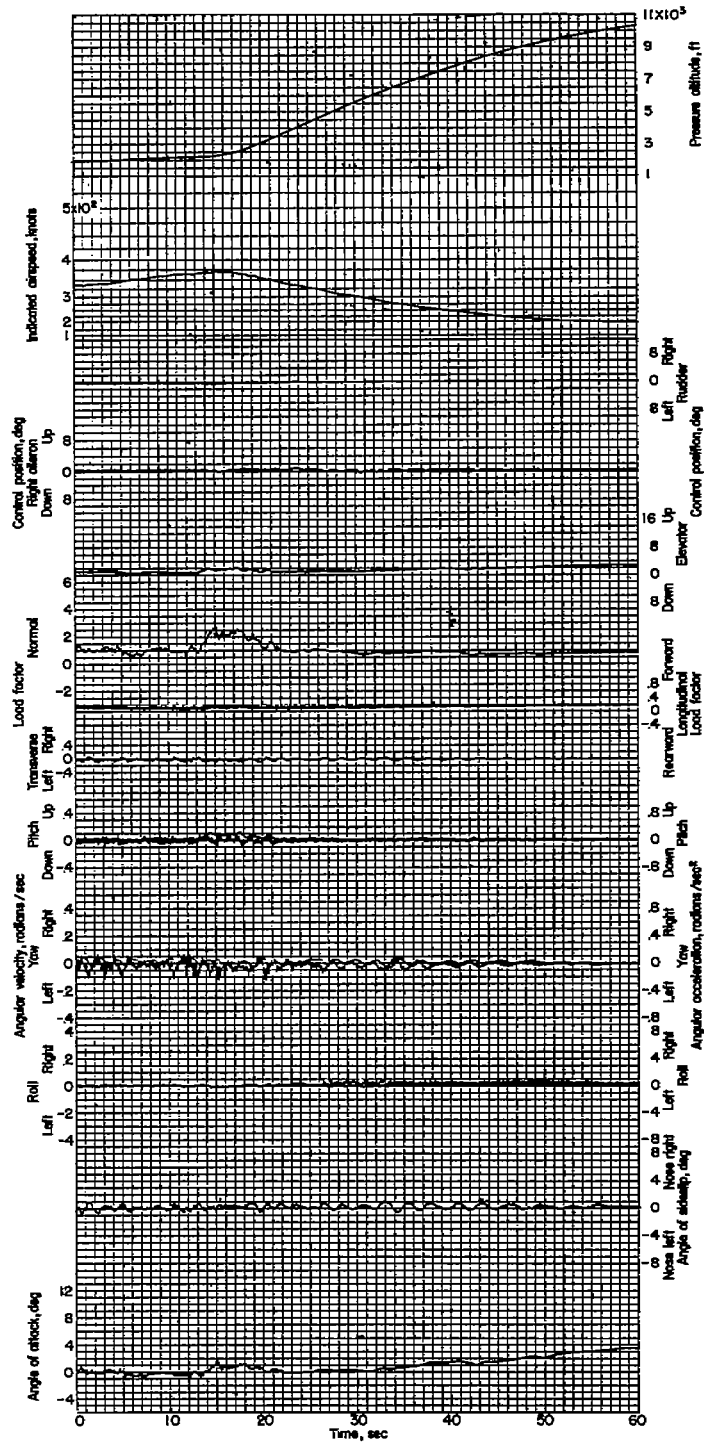


Figure 197.- Pull-up. Pilot H with radar observer; airplane weight, 13,090 pounds; center of gravity at 26.8 percent M.A.C.

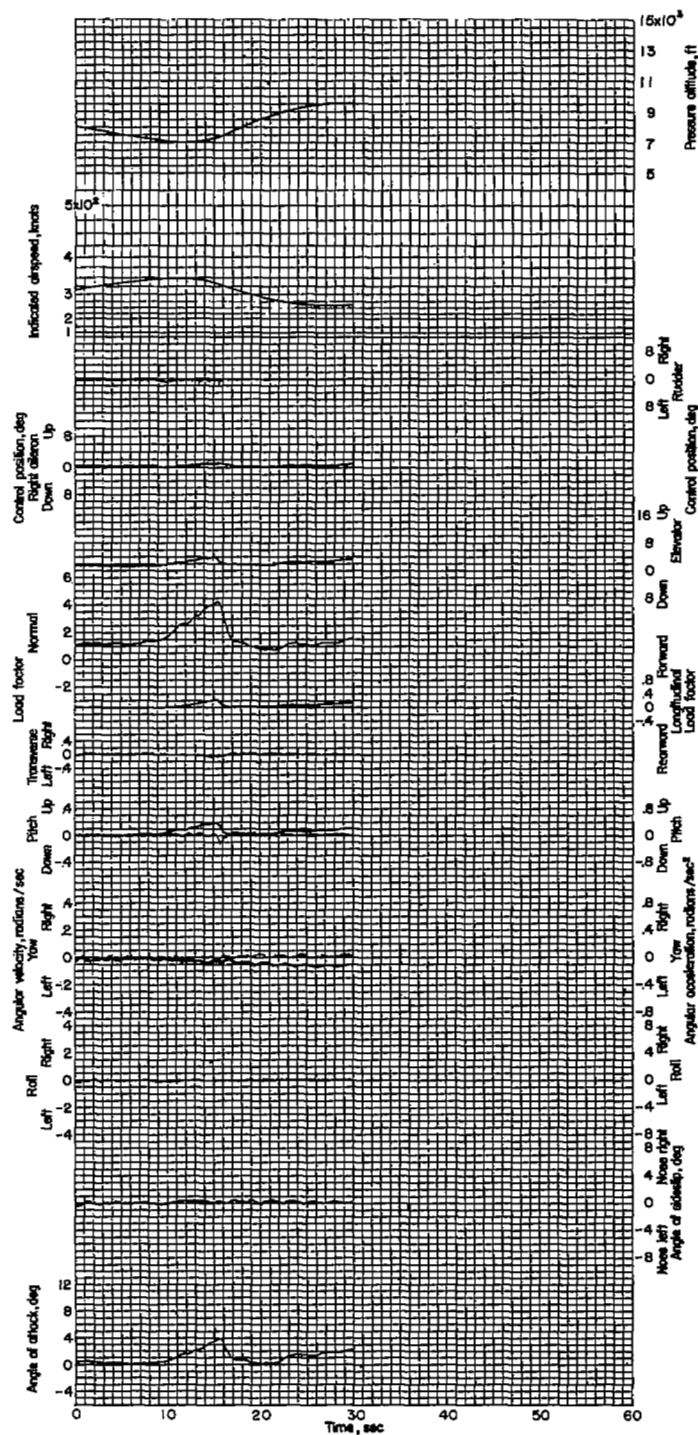


Figure 198.- Pull-up to the left. Pilot A; airplane weight, 11,980 pounds; center of gravity at 26.9 percent M.A.C.

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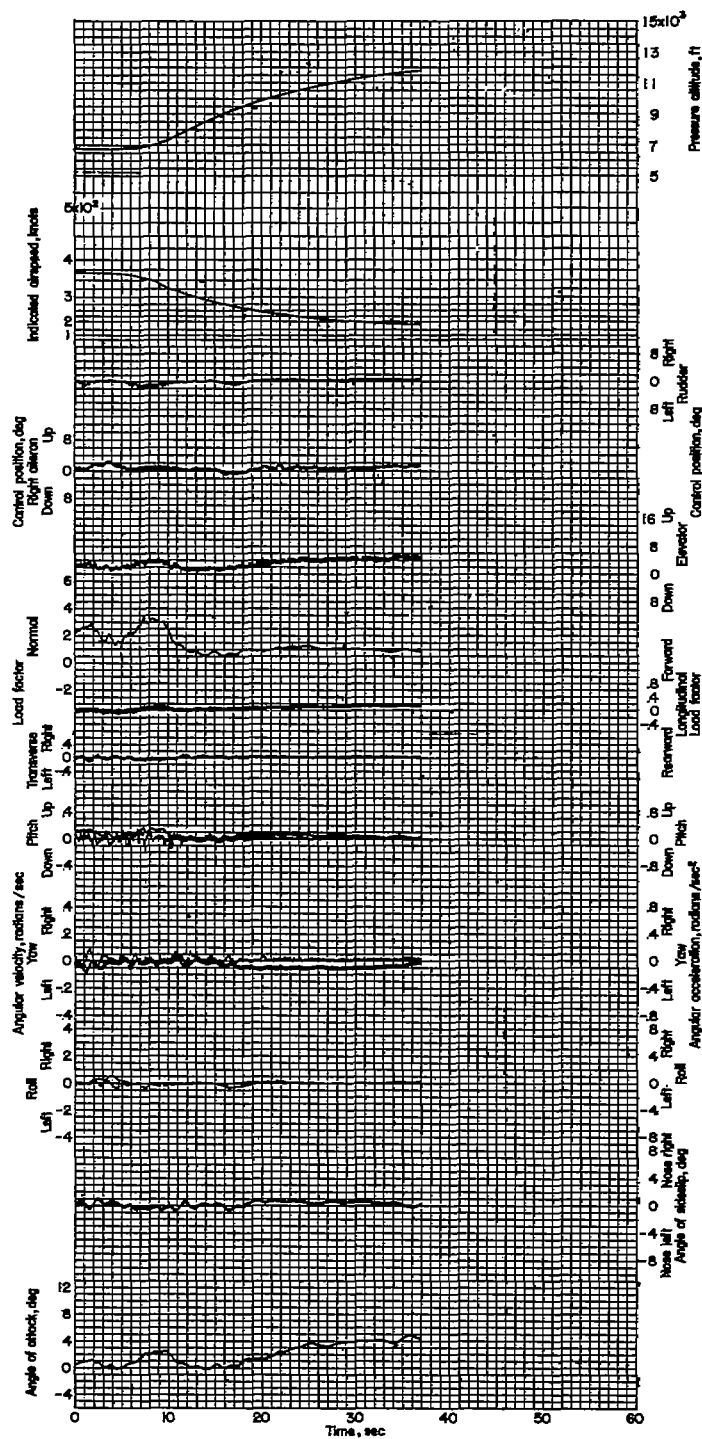


Figure 199.- Pull-up to the left. Pilot C with radar observer; airplane weight, 12,400 pounds; center of gravity at 26.4 percent M.A.C.

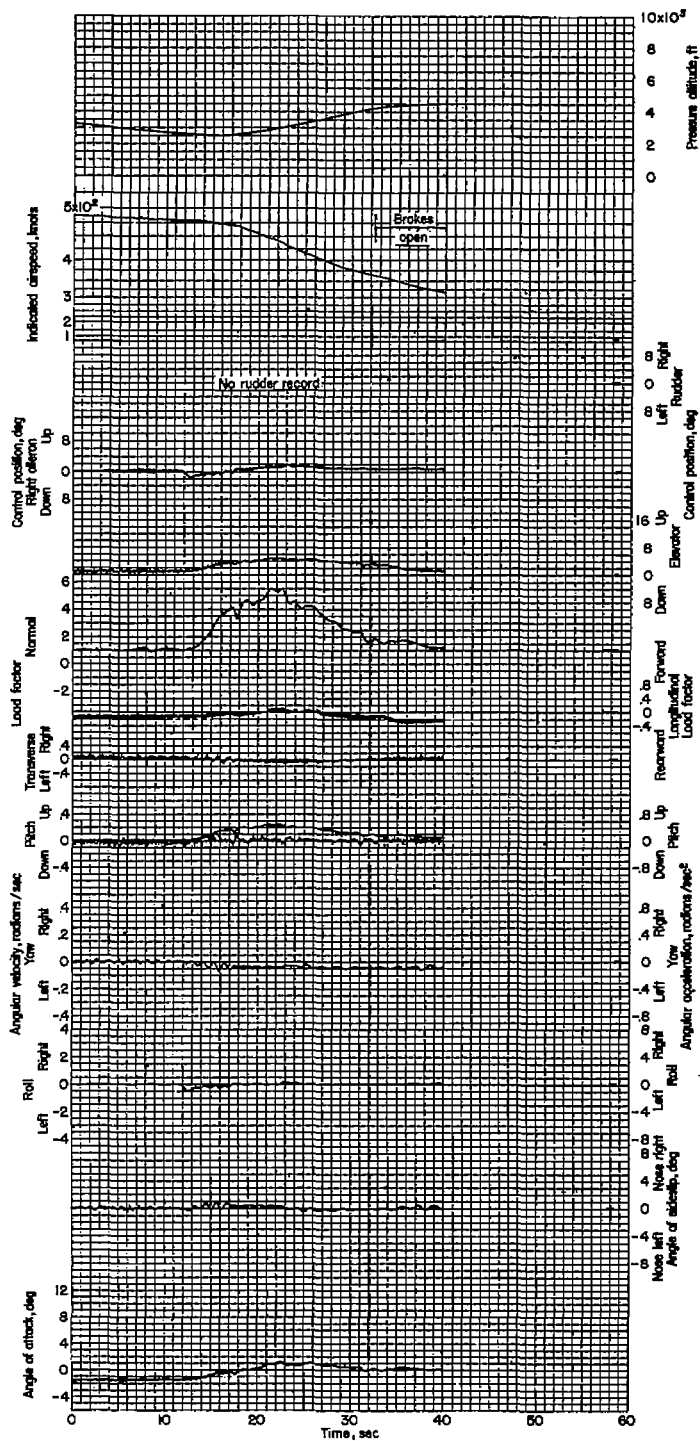


Figure 200.- Pull-up to the left. Pilot D with radar observer; airplane weight, 12,275 pounds; center of gravity at 26.1 percent M.A.C.

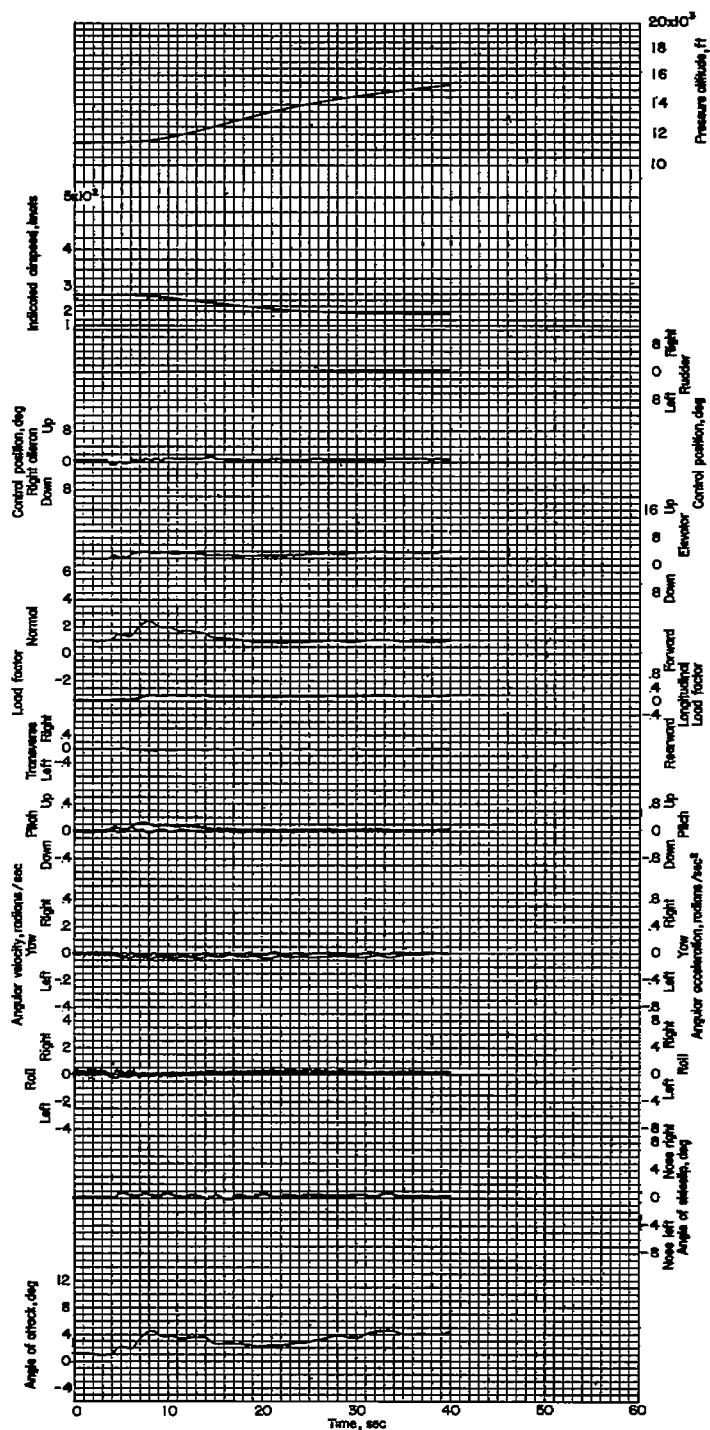


Figure 201.- Pull-up to the left. Pilot H with radar observer; airplane weight, 13,000 pounds; center of gravity at 26.8 percent M.A.C.

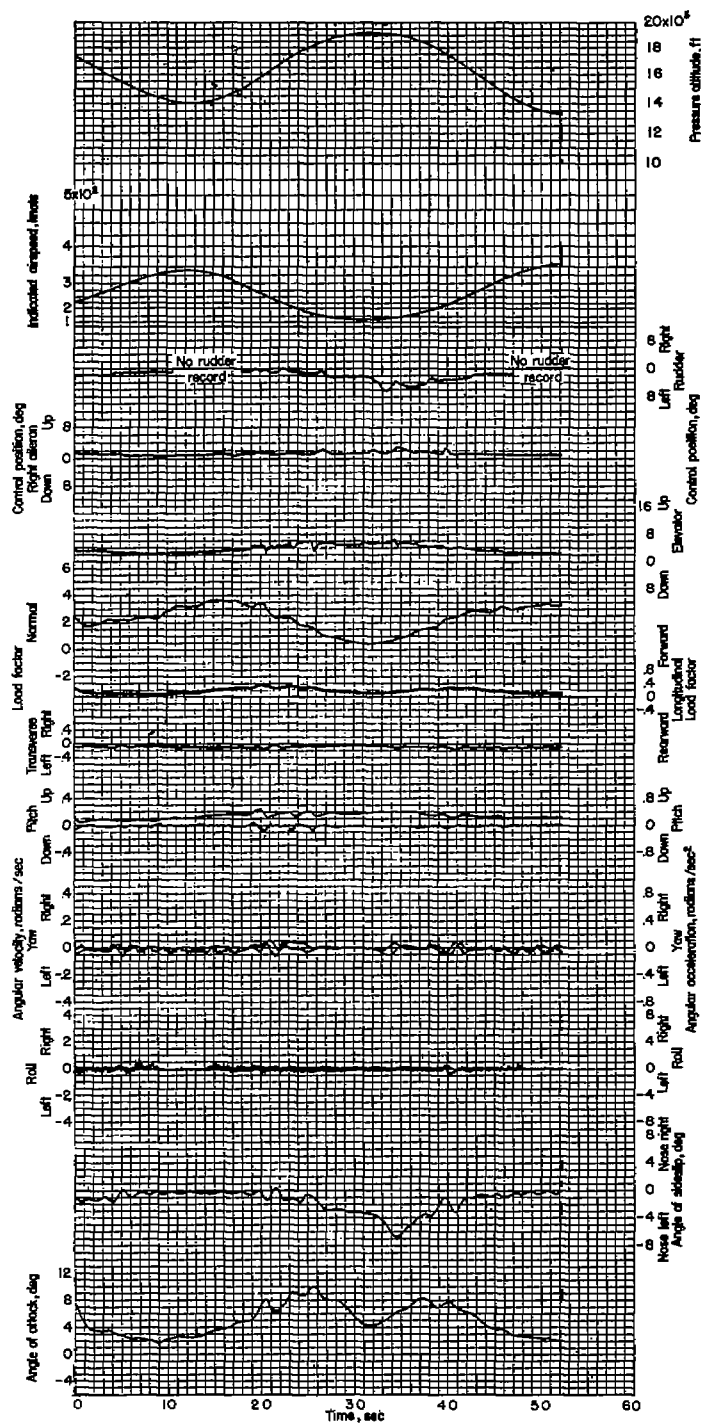


Figure 202.- Loop. Pilot A; airplane weight, 12,480 pounds; center of gravity at 27.8 percent M.A.C.



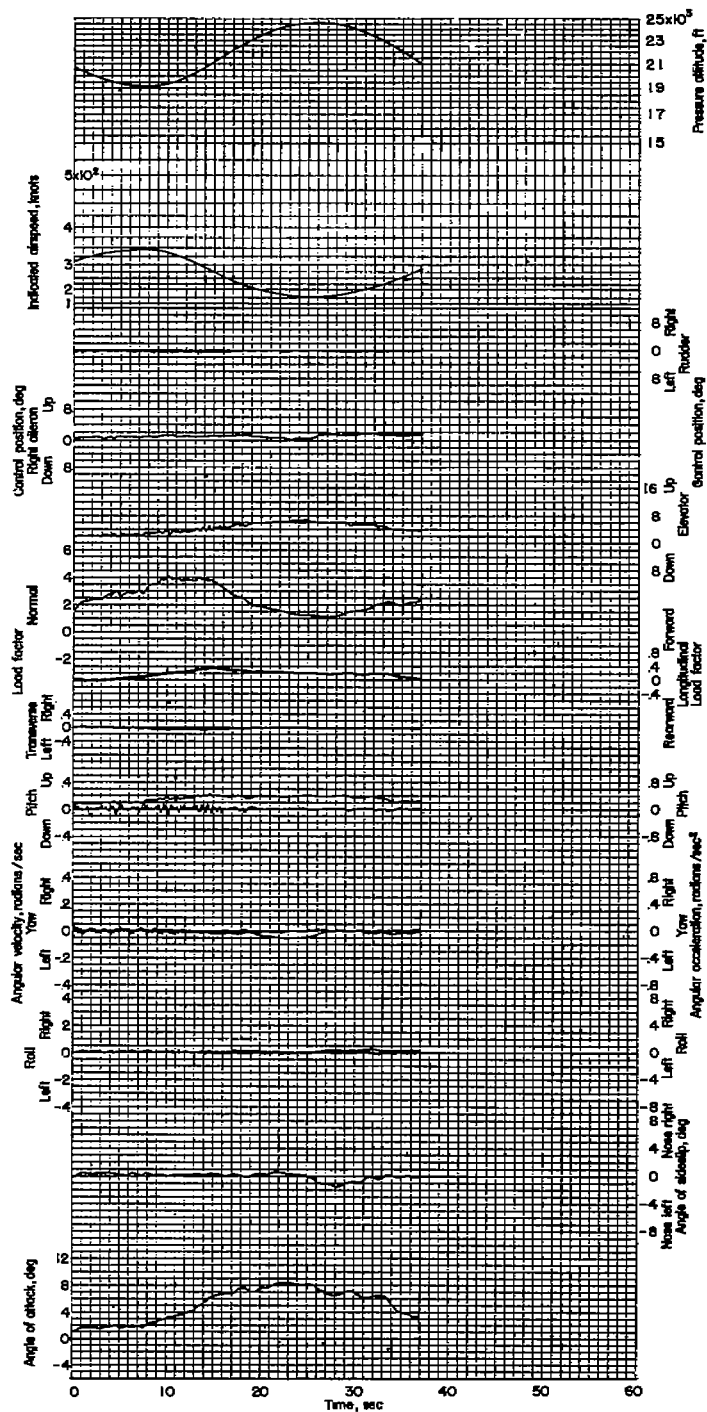


Figure 203.- Loop. Pilot B; airplane weight, 12,175 pounds; center of gravity at 27.2 percent M.A.C.

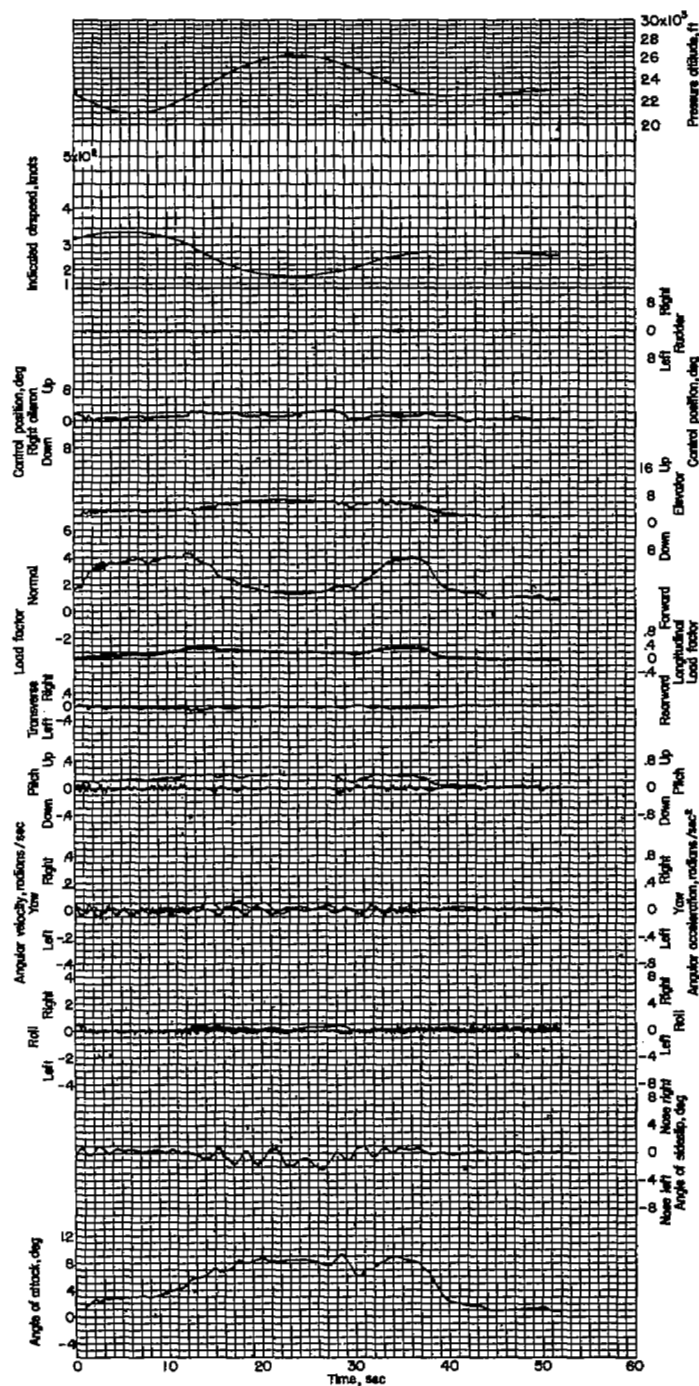
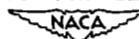


Figure 204.- Loop. Pilot B; airplane weight, 12,050 pounds; center of gravity at 27.0 percent M.A.C.



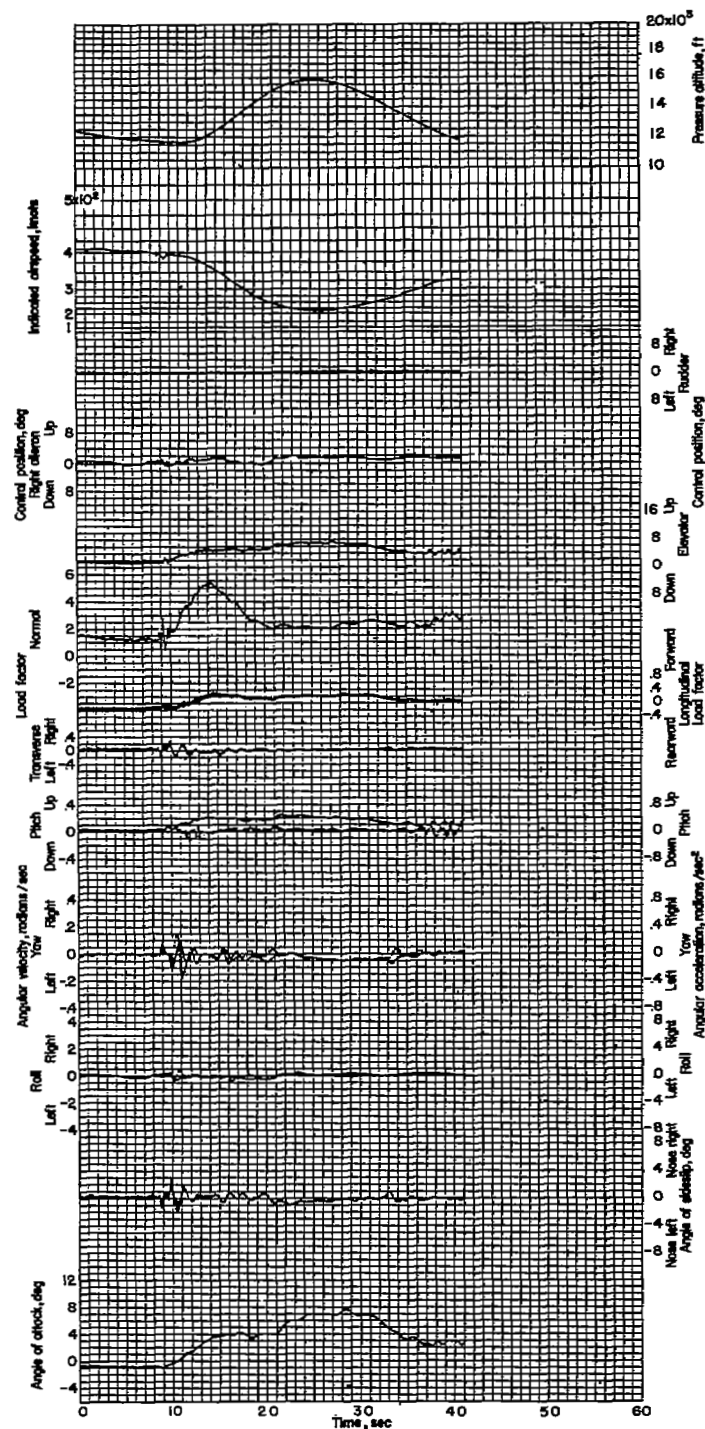
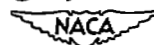


Figure 205.- Loop. Pilot B with radar observer; airplane weight, 12,050 pounds; center of gravity at 25.6 percent M.A.C.



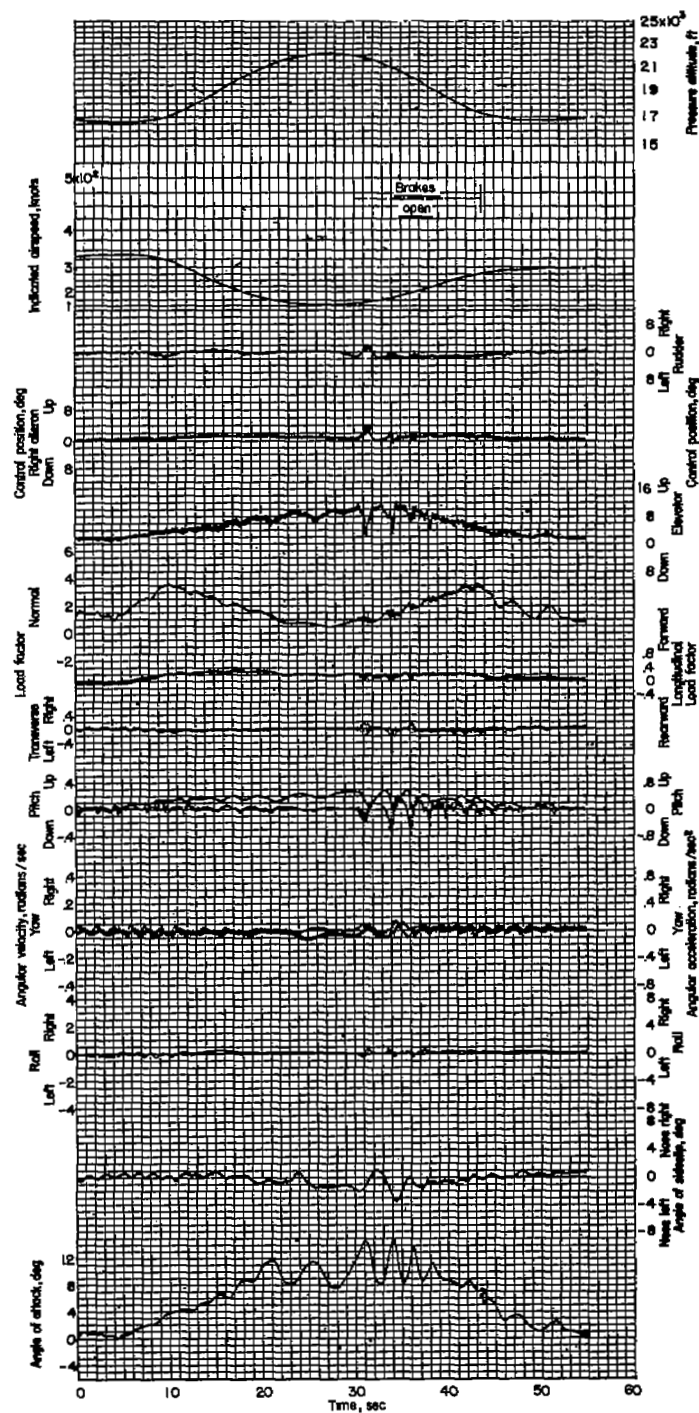


Figure 206.- Loop. Pilot C with radar observer; airplane weight, 12,640 pounds; center of gravity at 26.8 percent M.A.C.

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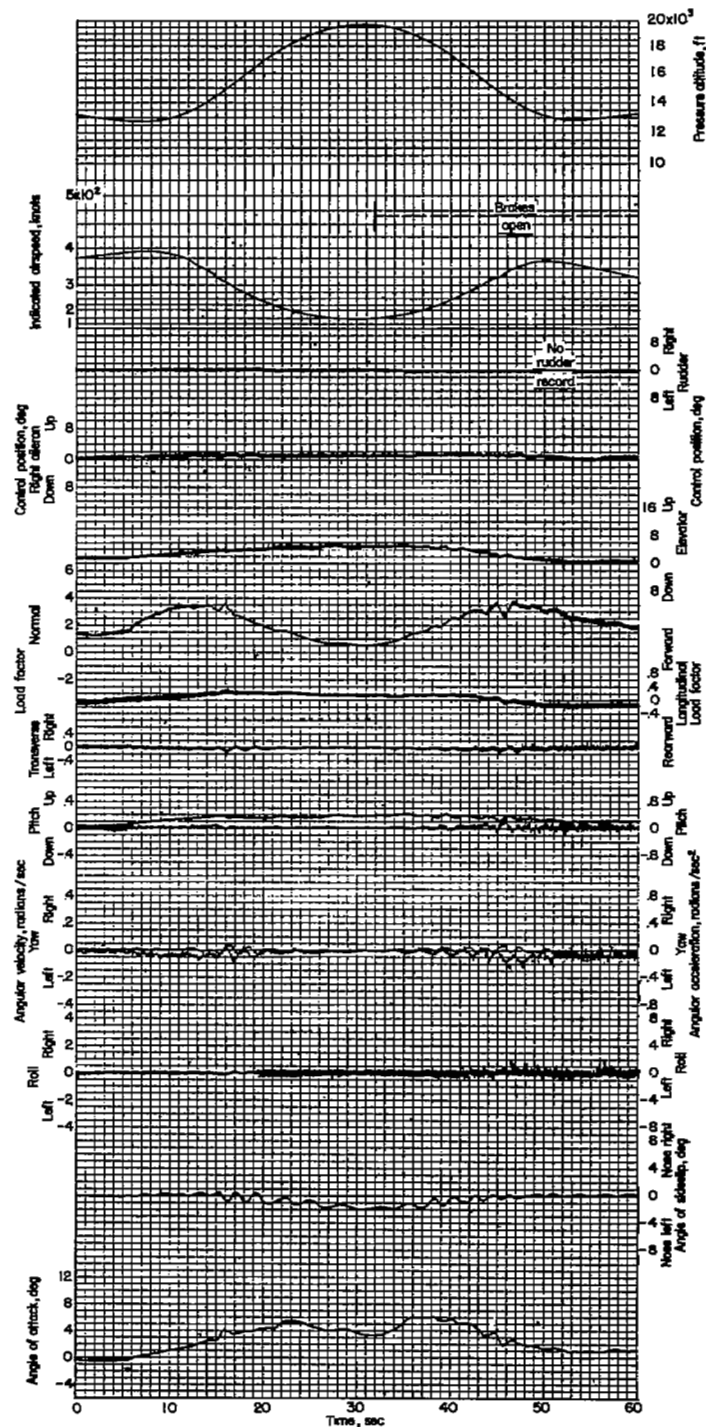


Figure 207.- Loop. Pilot F wearing anti-gravity suit and with radar observer; airplane weight, 12,350 pounds; center of gravity at 26.3 percent M.A.C.

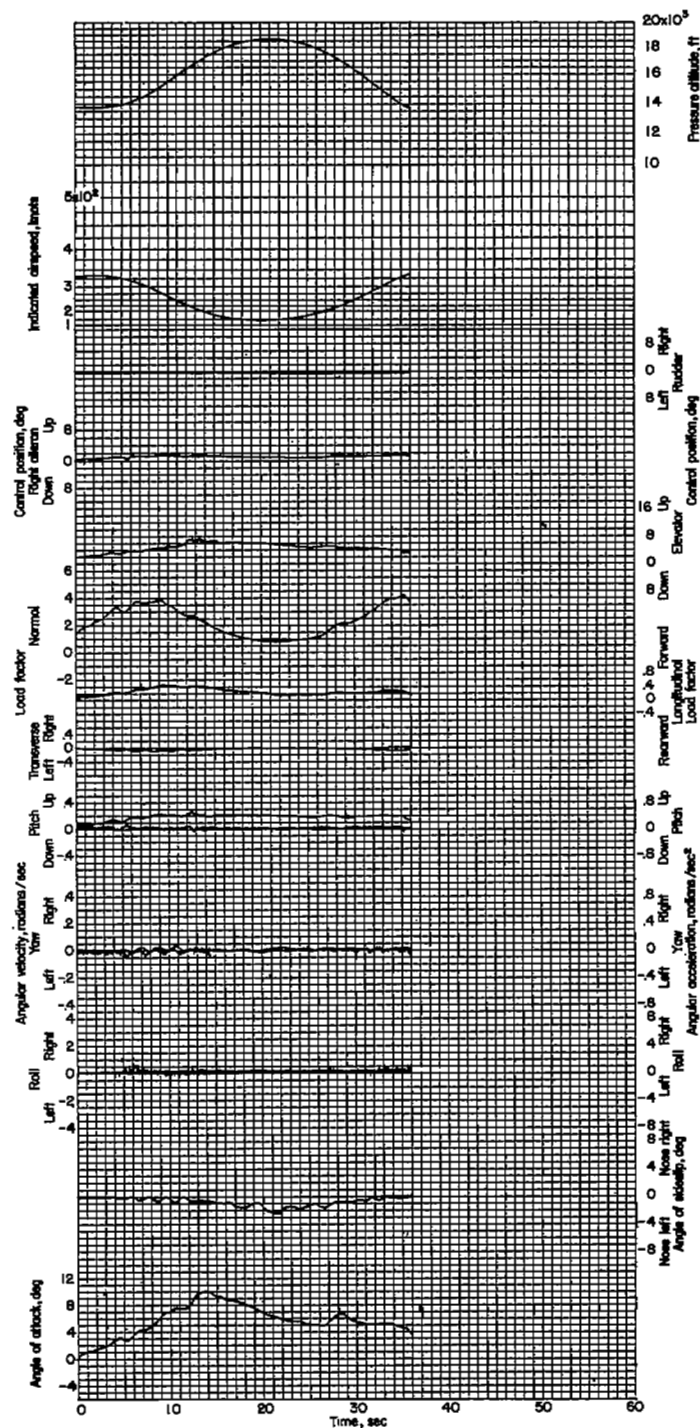
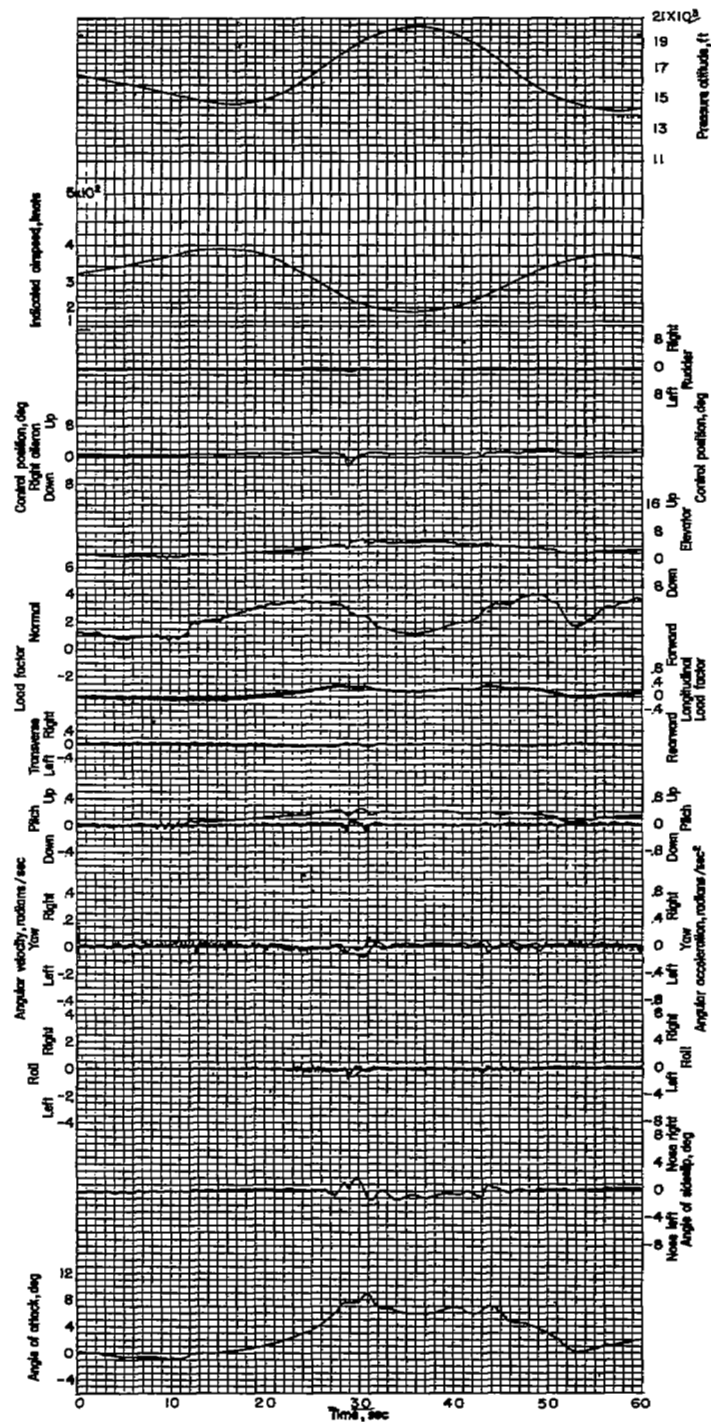


Figure 208.- Loop. Pilot H with radar observer; airplane weight, 12,400 pounds; center of gravity at 26.4 percent M.A.C.

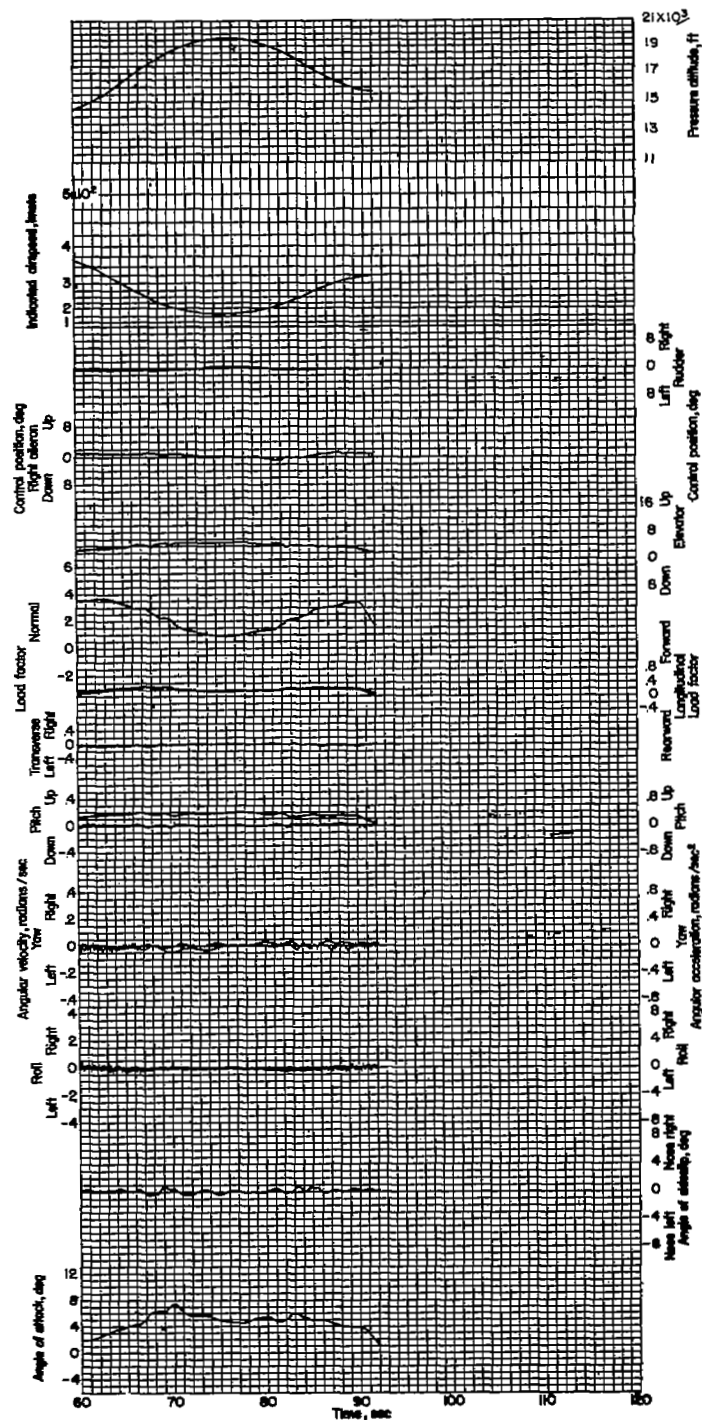
NACA



(a)



Figure 209.- Two loops. Pilot E wearing anti-gravity suit; airplane weight, 12,370 pounds; center of gravity at 27.6 percent M.A.C.



(b)



Figure 209.- Concluded.

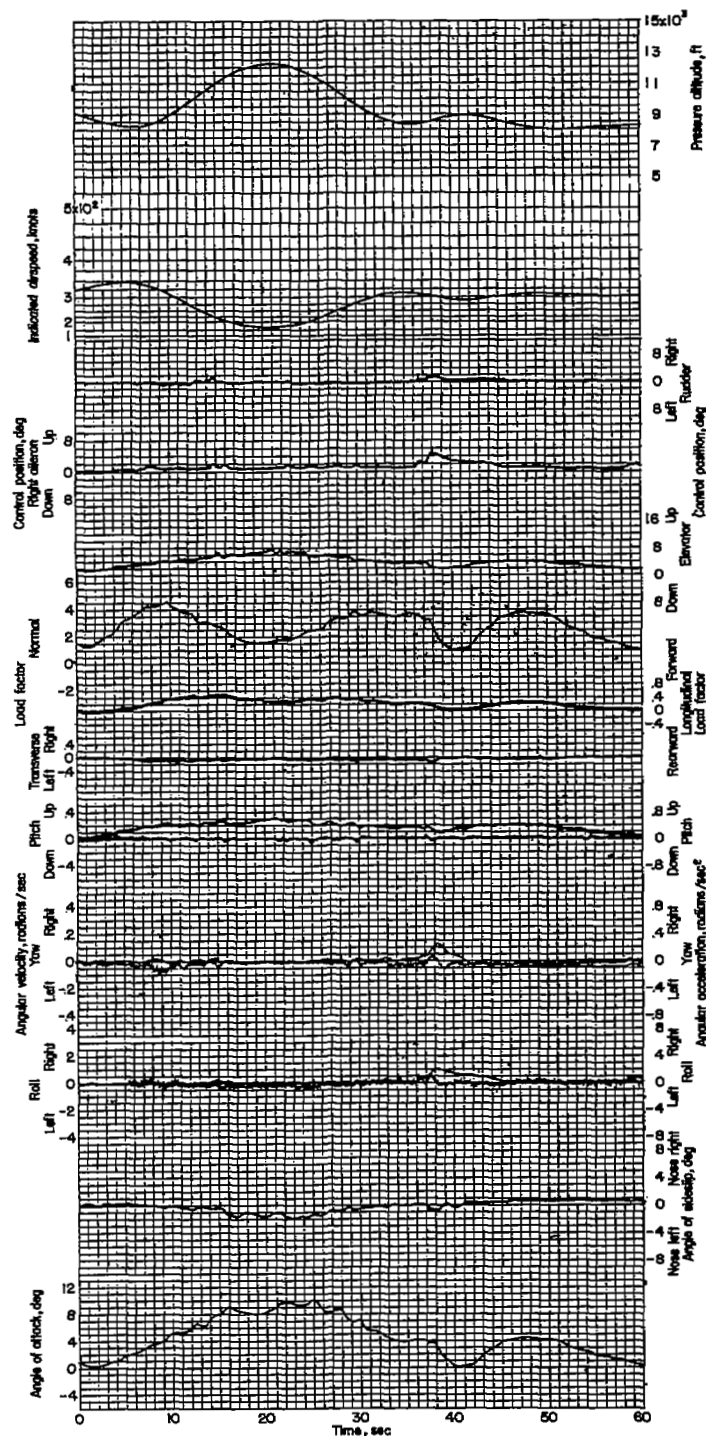


Figure 210.- Loop followed by partial right barrel roll. Pilot A wearing anti-gravity suit; airplane weight, 11,940 pounds; center of gravity at 26.8 percent M.A.C.

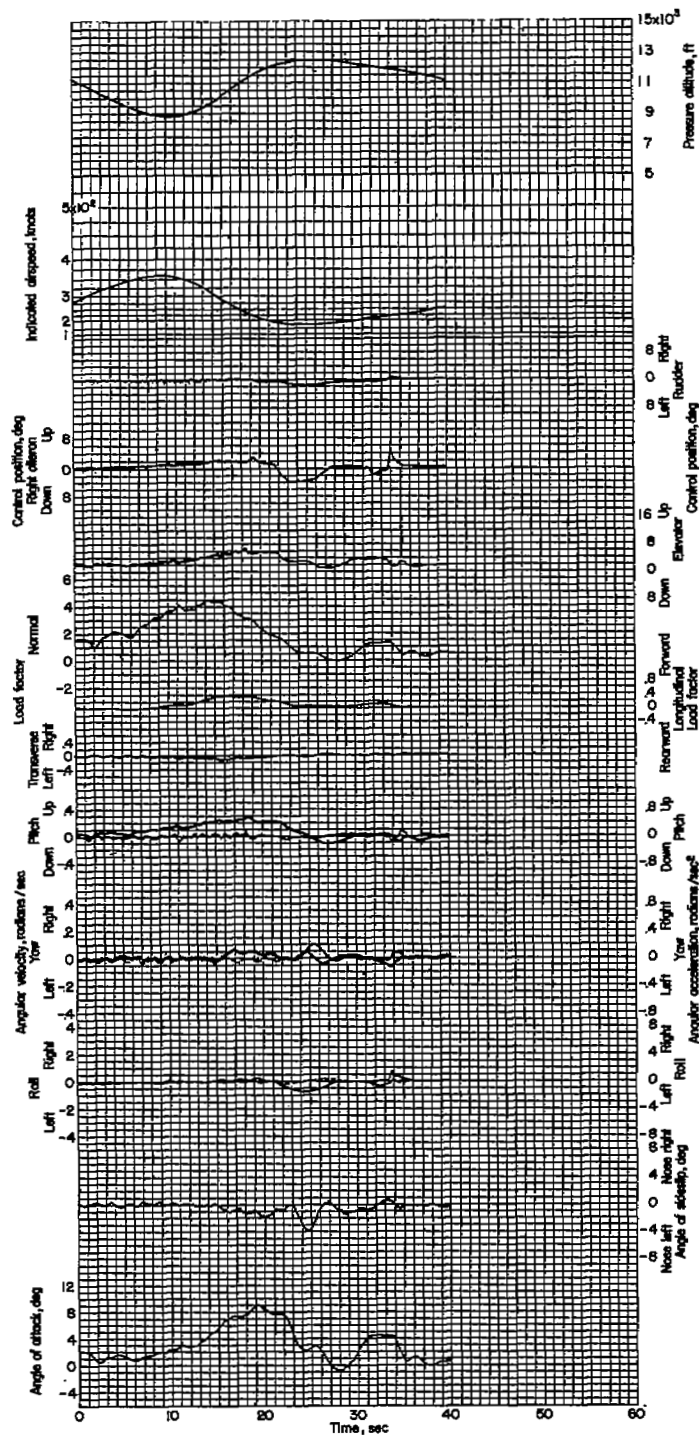


Figure 211.- Immelman. Pilot A; airplane weight, 12,060 pounds; center of gravity at 27.0 percent M.A.C.



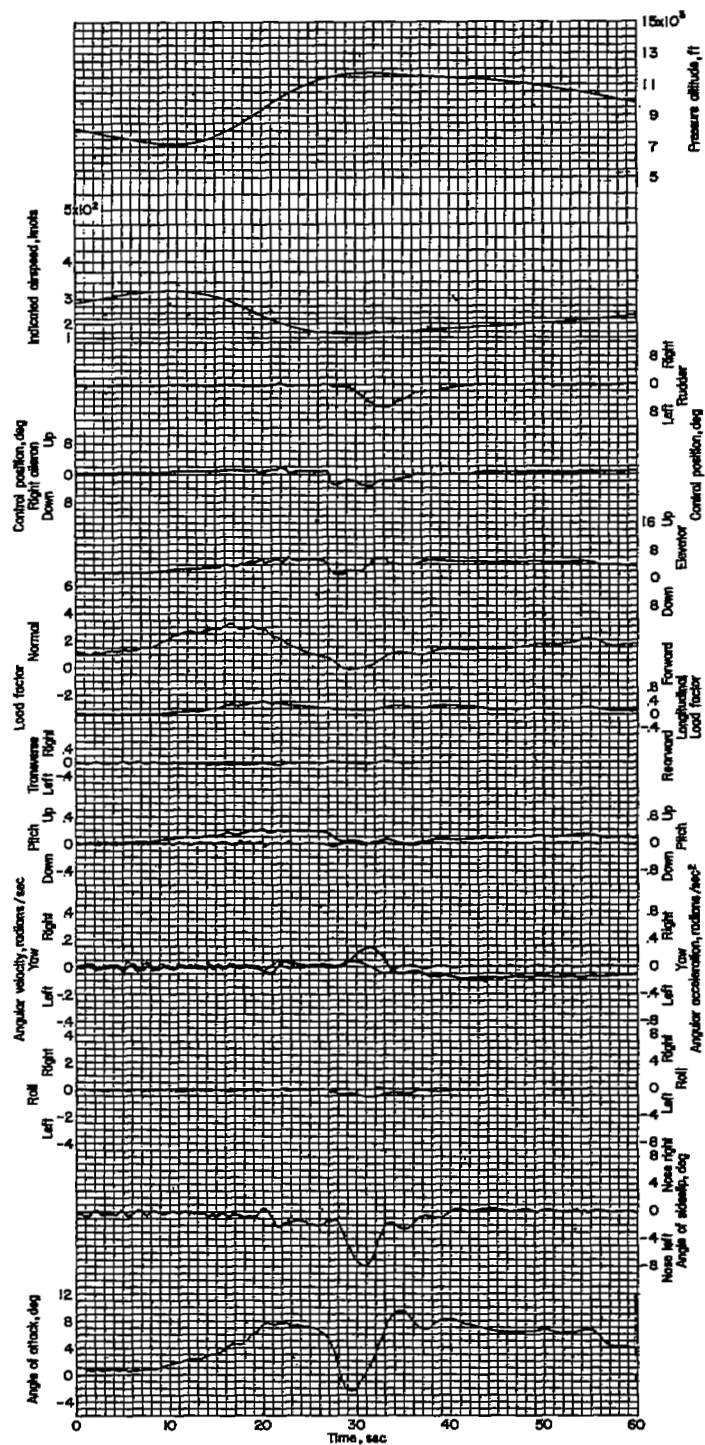
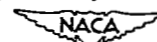


Figure 212.- Immelman. Pilot A; airplane weight, 12,010 pounds; center of gravity at 26.9 percent M.A.C.



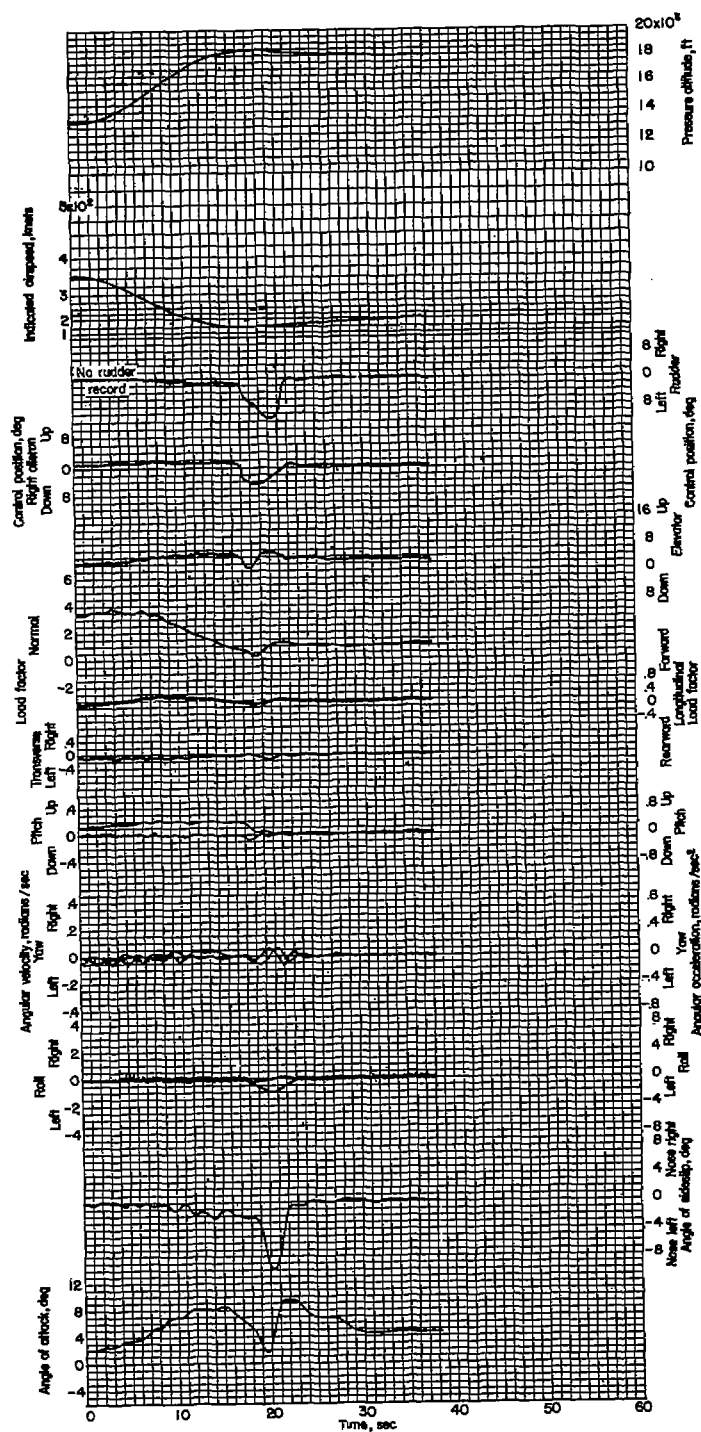


Figure 213.- Immelman. Pilot A; airplane weight, 12,440 pounds; center of gravity at 27.7 percent M.A.C.

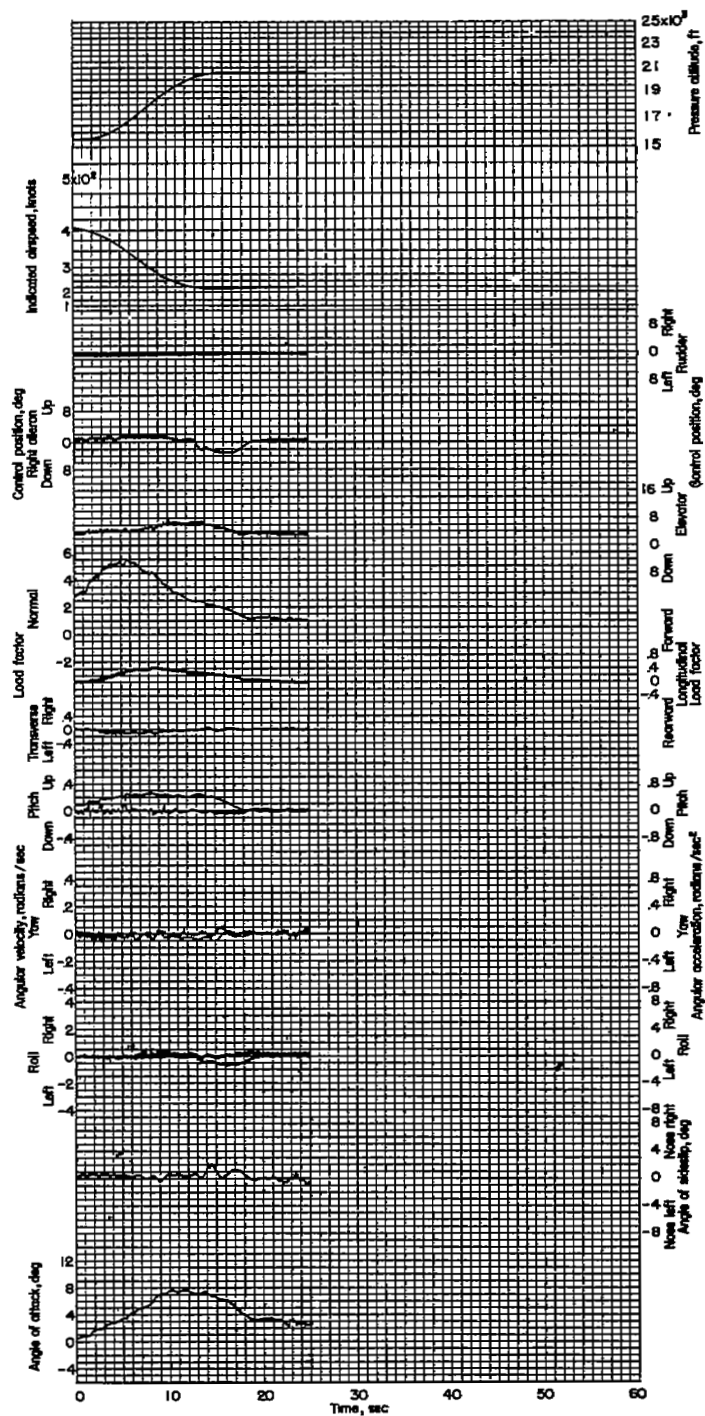
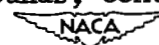


Figure 214.- Immelman. Pilot B; airplane weight, 11,930 pounds; center of gravity at 26.7 percent M.A.C.



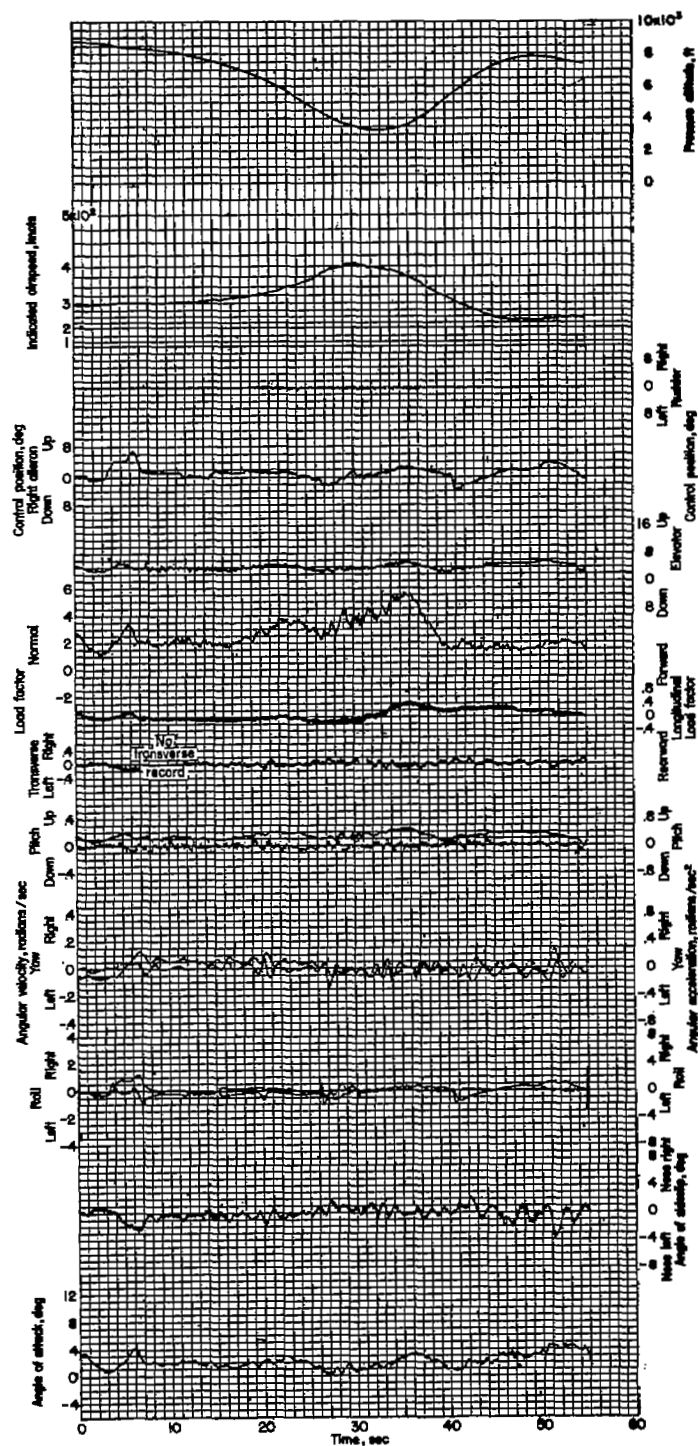
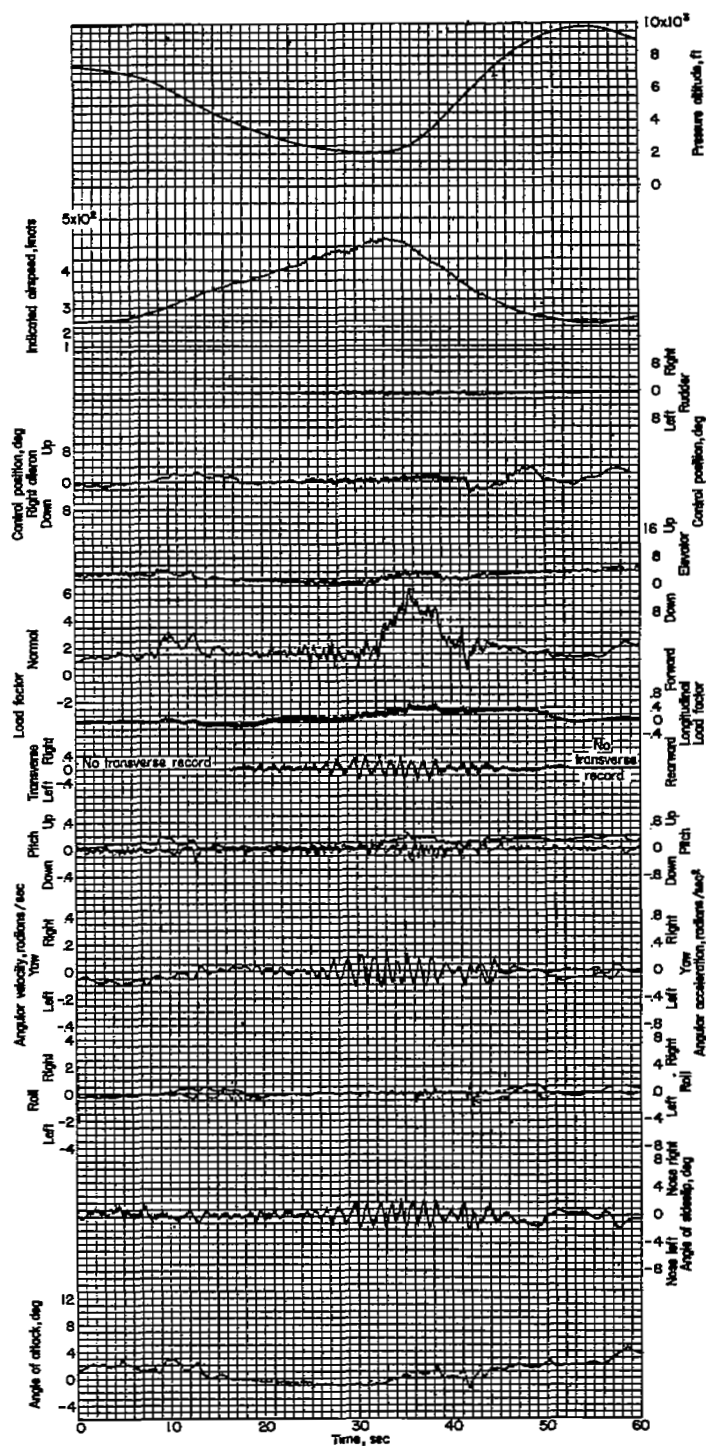


Figure 215.- Immelman. Pilot B with radar observer; airplane weight, 11,980 pounds; center of gravity at 25.5 percent M.A.C.

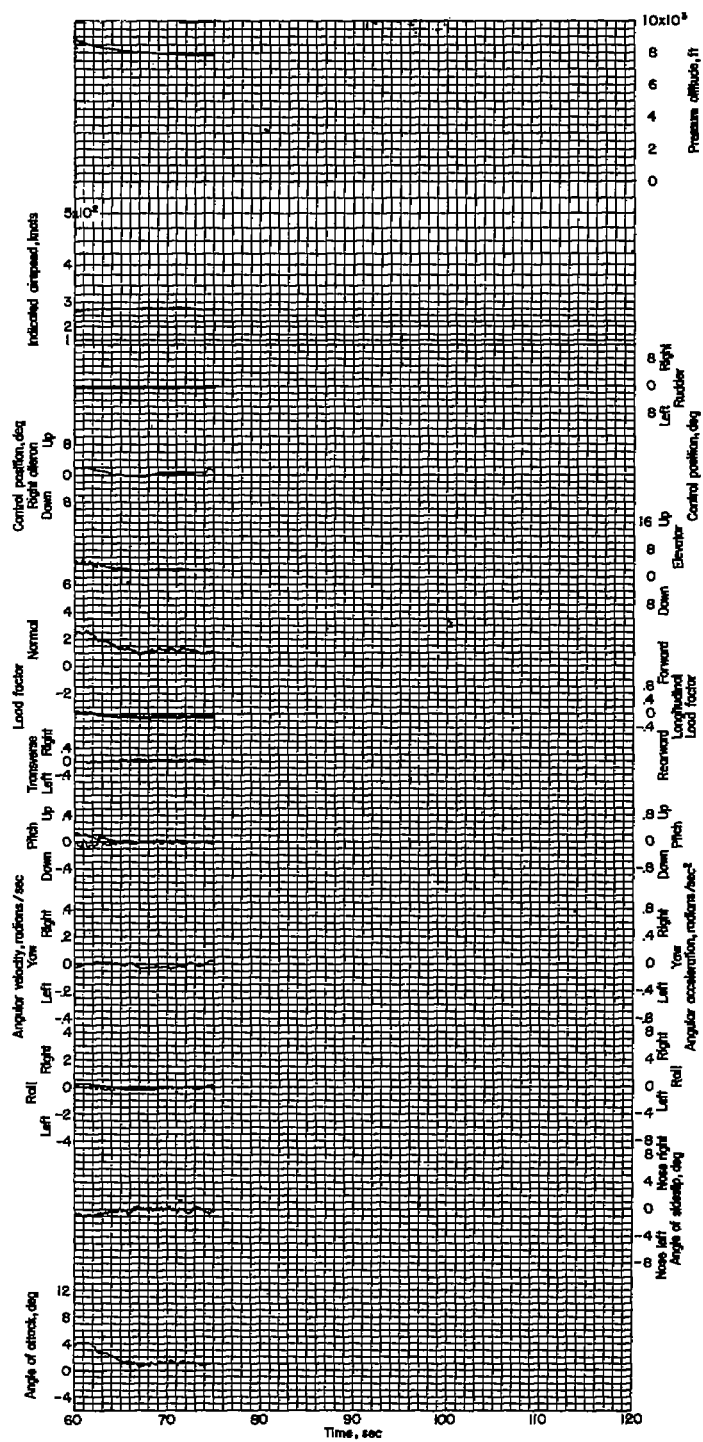
2V



(a)



Figure 216.- Immelman. Pilot B with radar observer; airplane weight, 11,950 pounds; center of gravity at 25.4 percent M.A.C.



(b)



Figure 216.- Concluded.

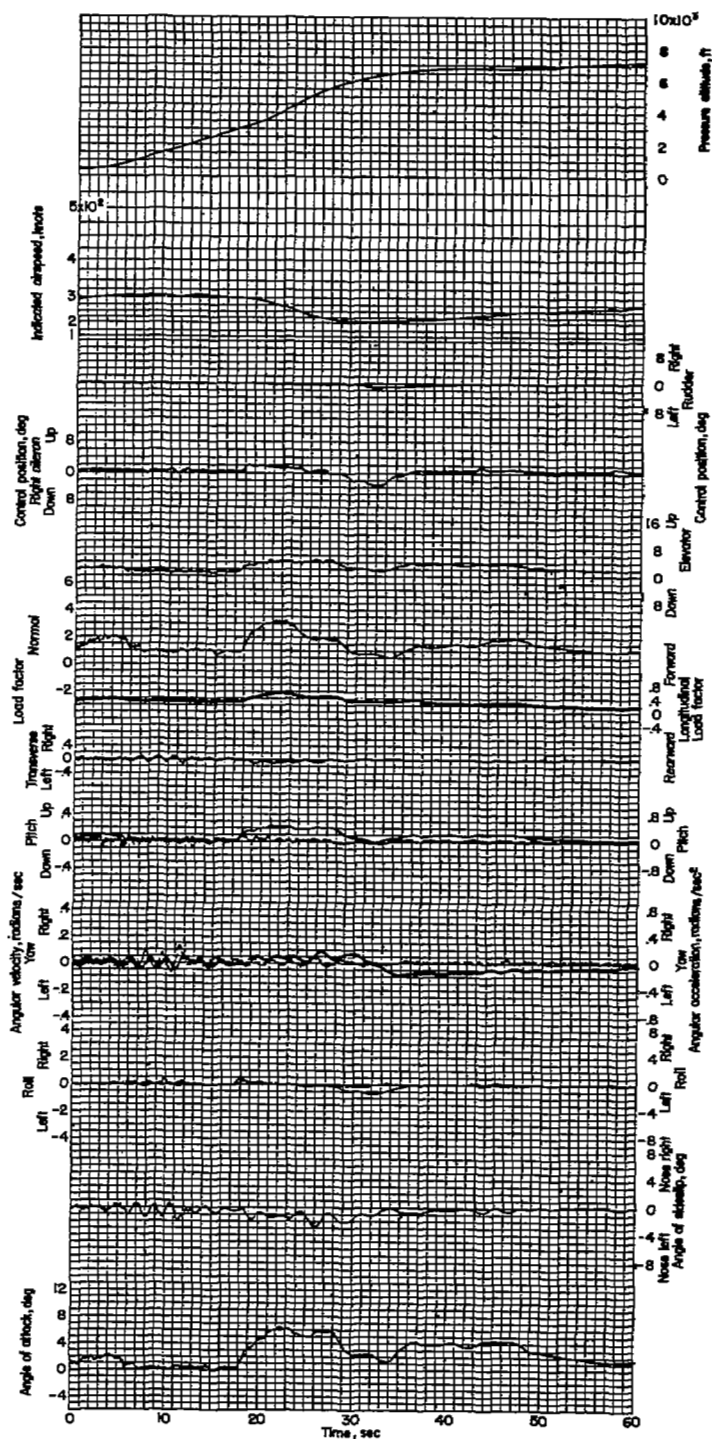


Figure 217.- Immelman. Pilot D with radar observer; airplane weight, 12,950 pounds; center of gravity at 26.9 percent M.A.C.

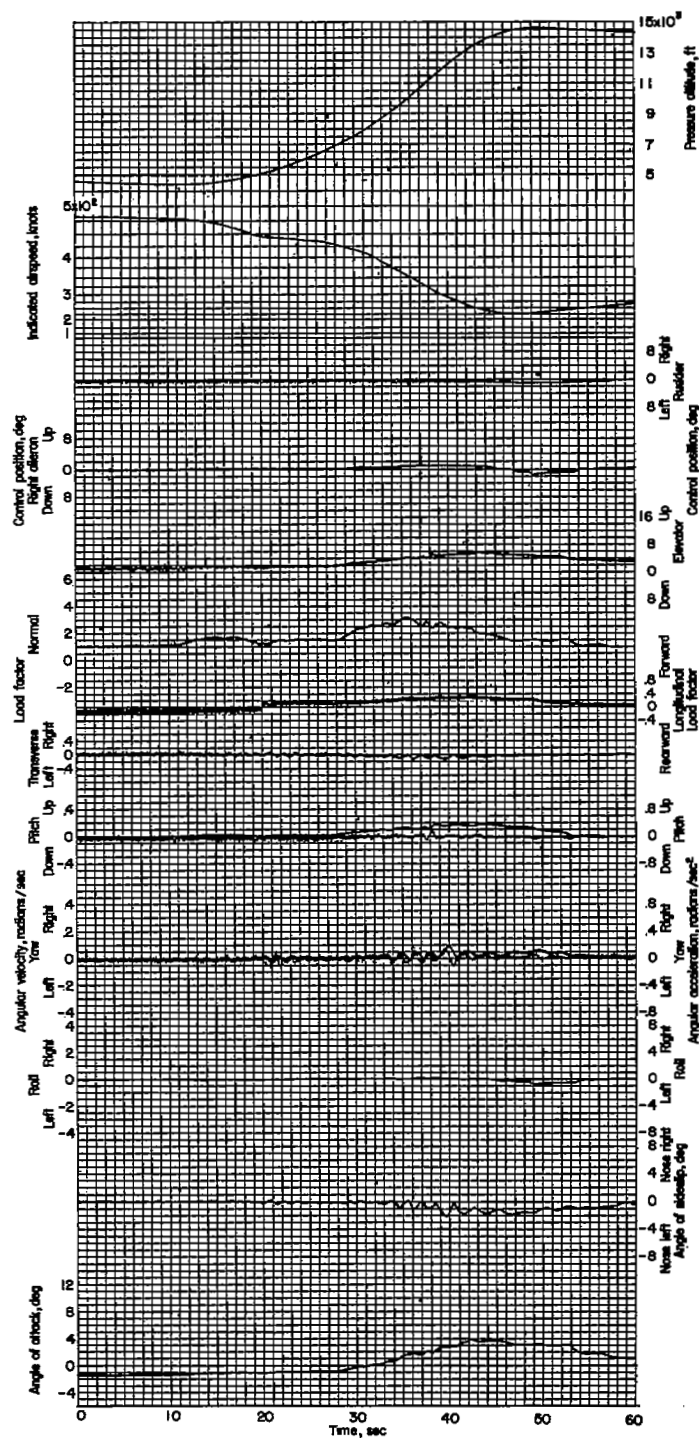


Figure 218.- Immelman. Pilot D with radar observer; airplane weight, 12,100 pounds; center of gravity at 25.7 percent M.A.C.

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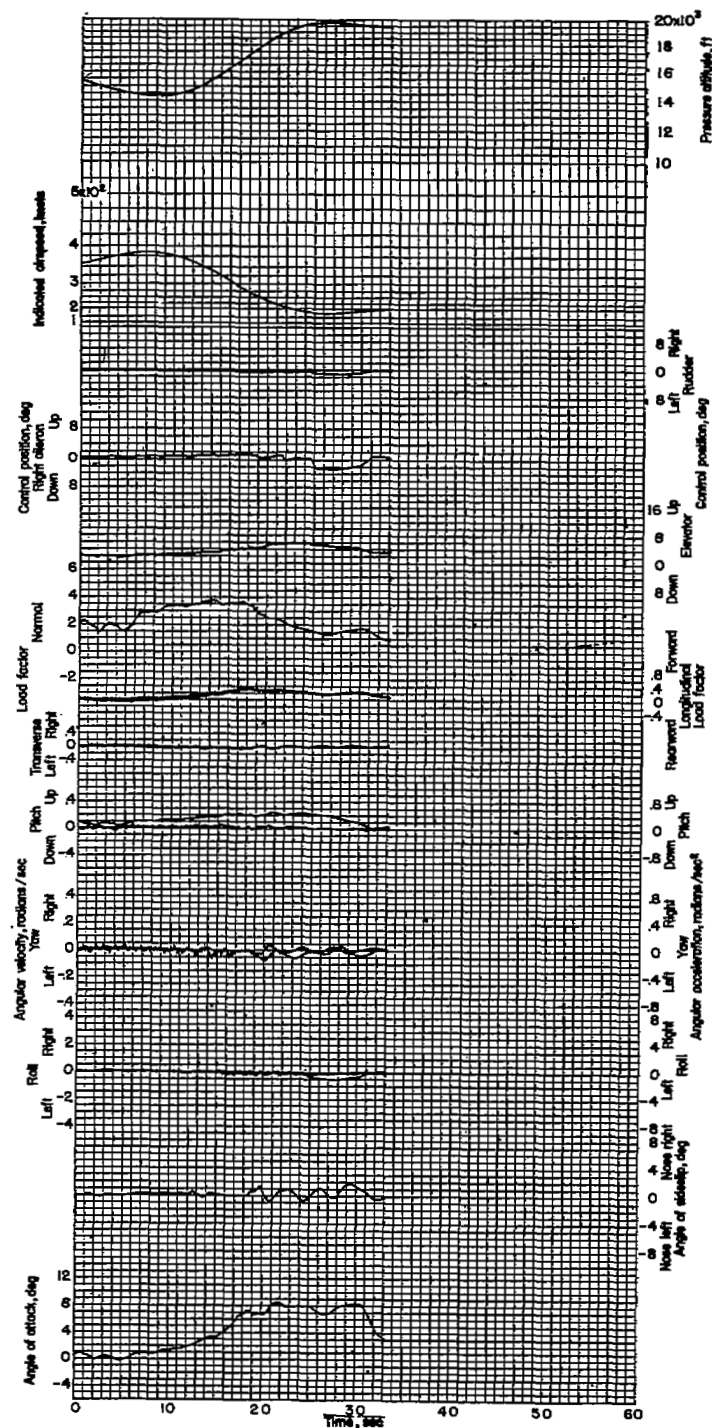


Figure 219.- Immelman. Pilot E wearing anti-gravity suit; airplane weight, 12,440 pounds; center of gravity at 27.7 percent M.A.C.

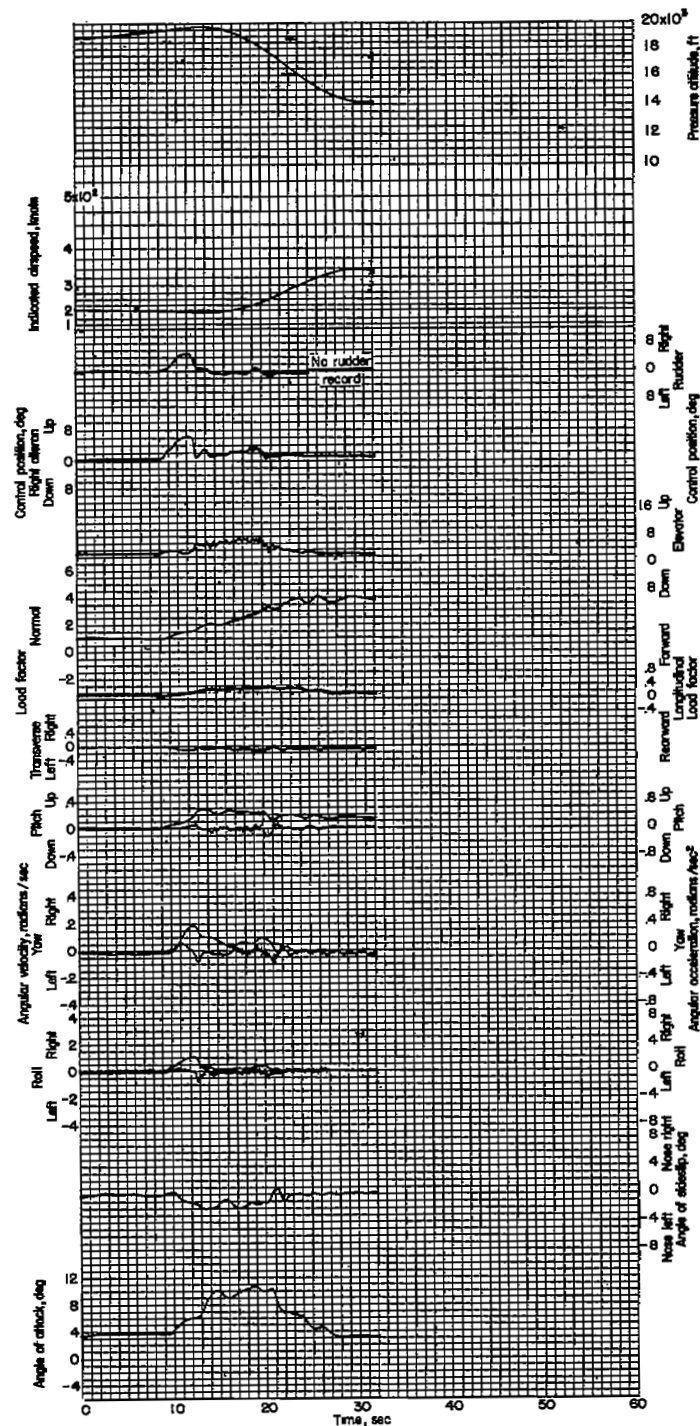


Figure 220.- Split-S. Pilot A; airplane weight, 12,400 pounds; center of gravity at 27.6 percent M.A.C.

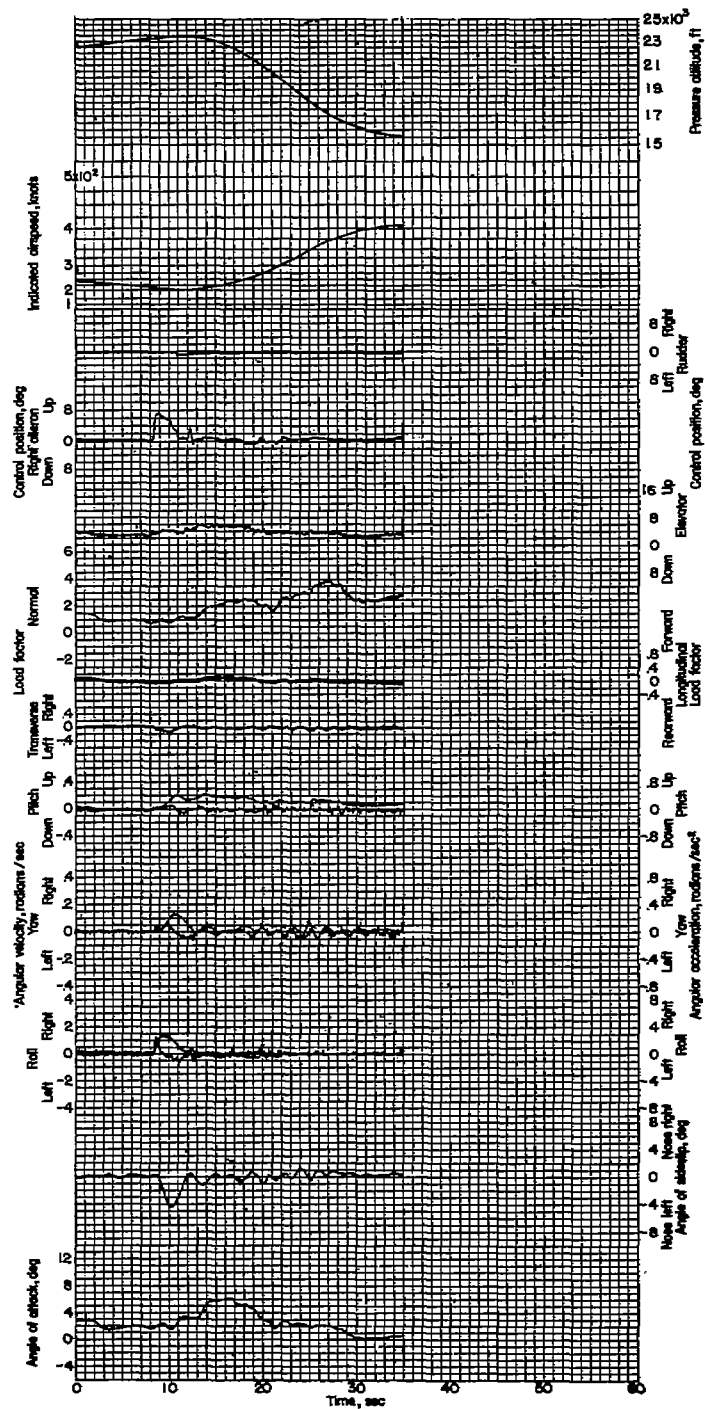


Figure 221.- Split-S. Pilot B; airplane weight, 11,950 pounds; center of gravity at 26.8 percent M.A.C.

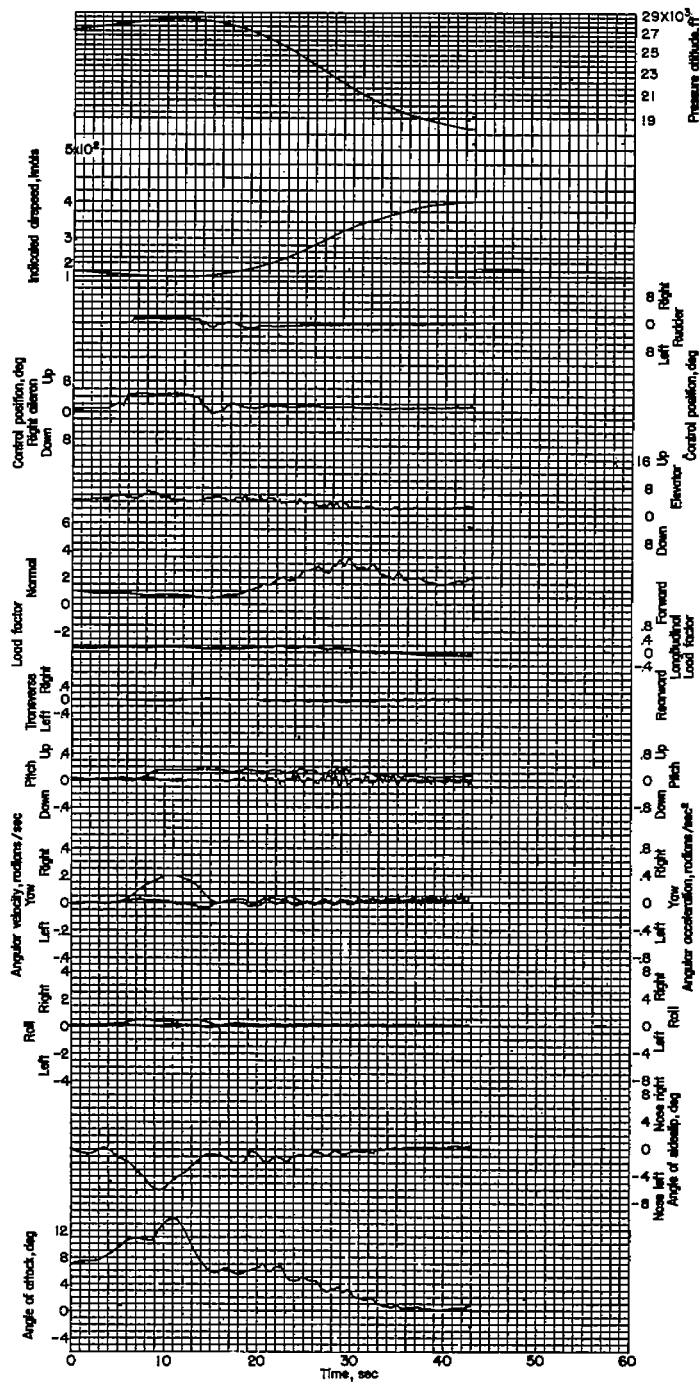


Figure 222.- Split-S. Pilot B; airplane weight, 12,240 pounds; center of gravity at 27.4 percent M.A.C.



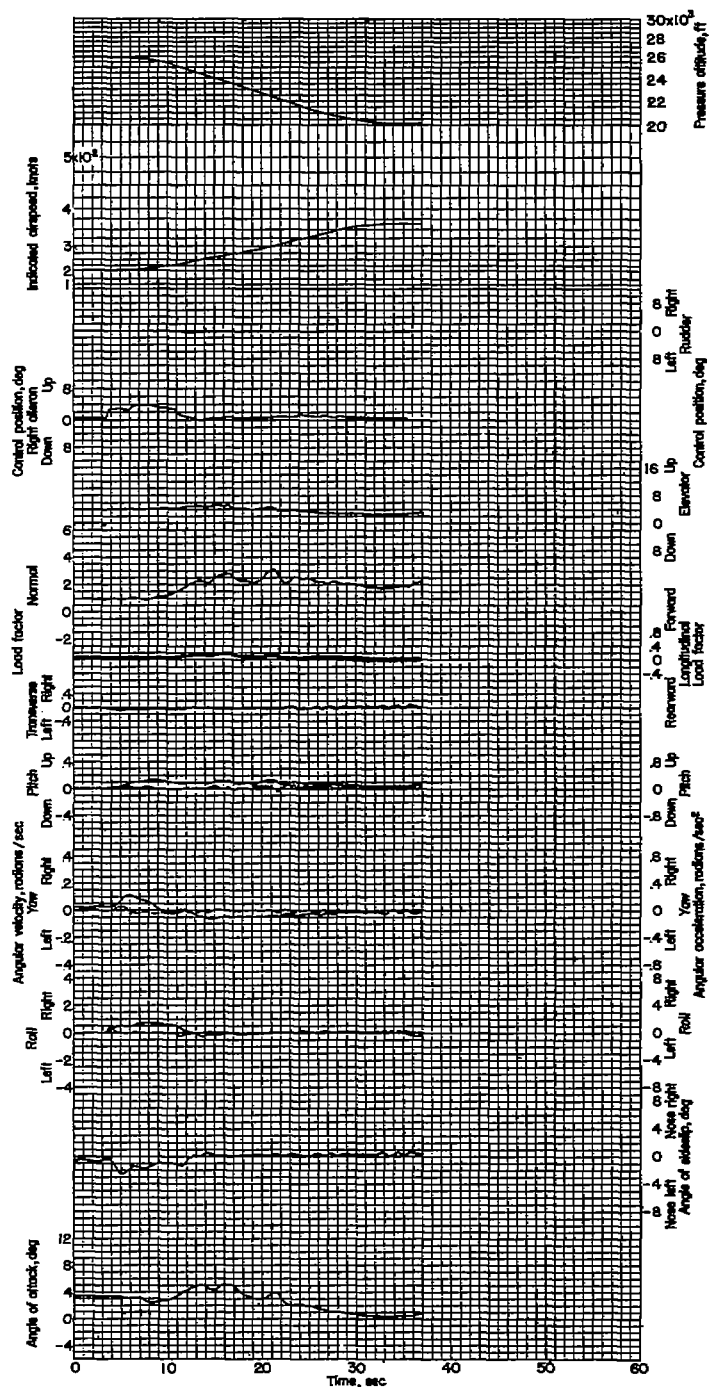


Figure 223.- Split-S. Pilot B with radar observer; airplane weight, 12,140 pounds; center of gravity at 25.8 percent M.A.C.



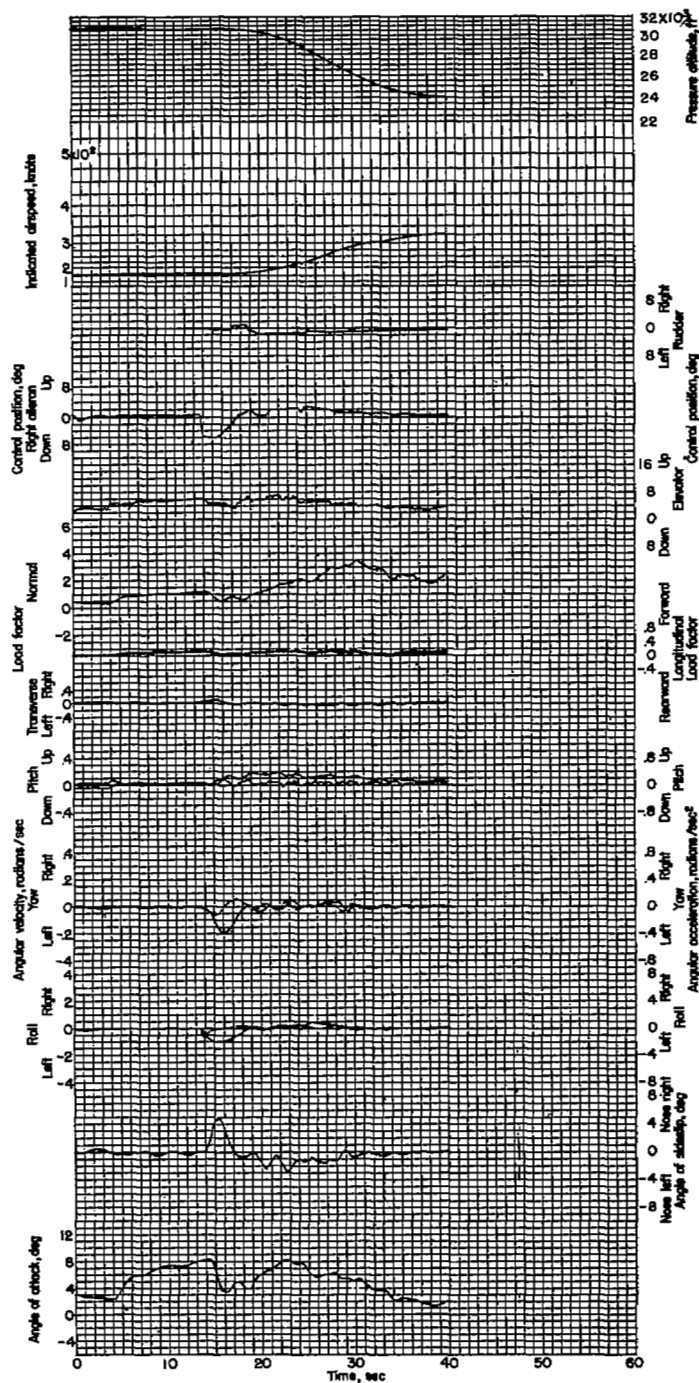


Figure 224.- Split-S. Pilot B with radar observer; airplane weight, 12,205 pounds; center of gravity at 26.0 percent M.A.C.

NACA

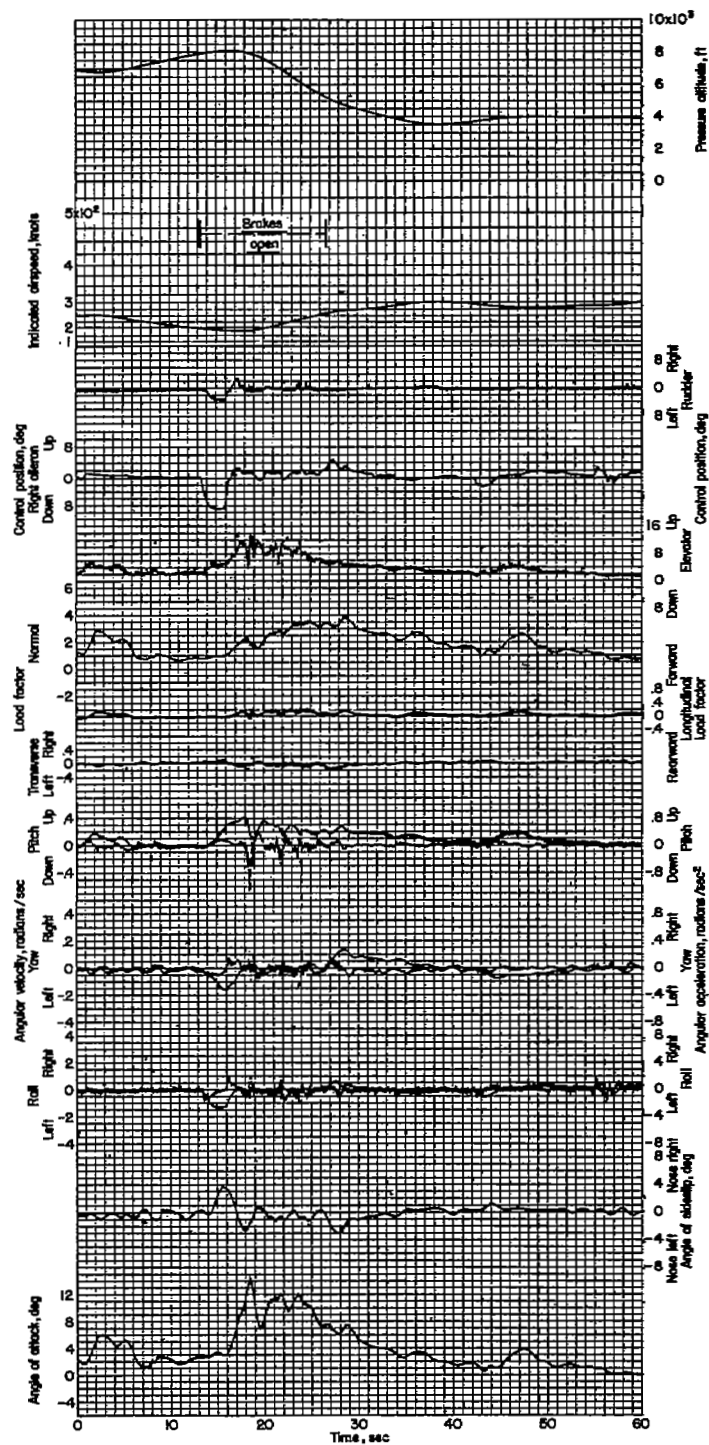


Figure 225.- Split-S. Pilot G; airplane weight, 12,420 pounds; center of gravity at 27.7 percent M.A.C.

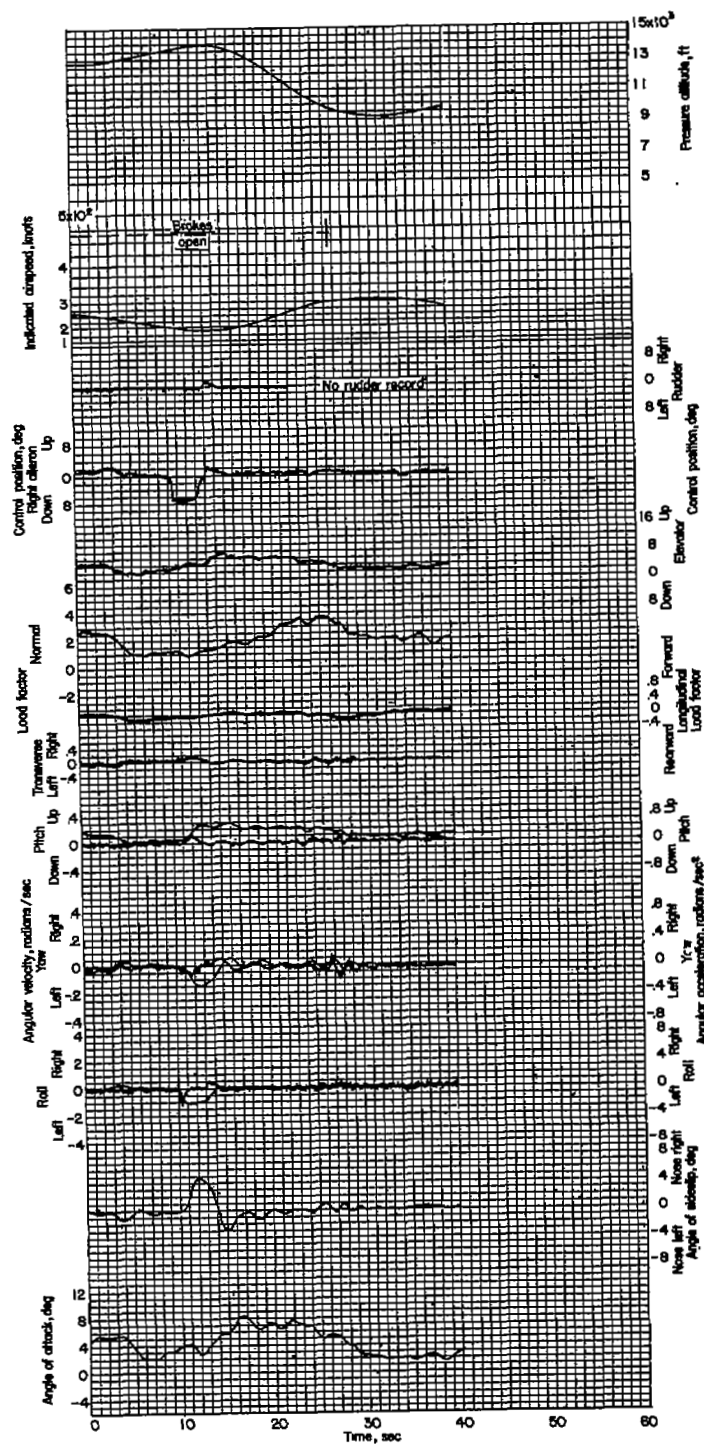


Figure 226.- Split-S. Pilot G; airplane weight, 11,850 pounds; center of gravity at 26.6 percent M.A.C.

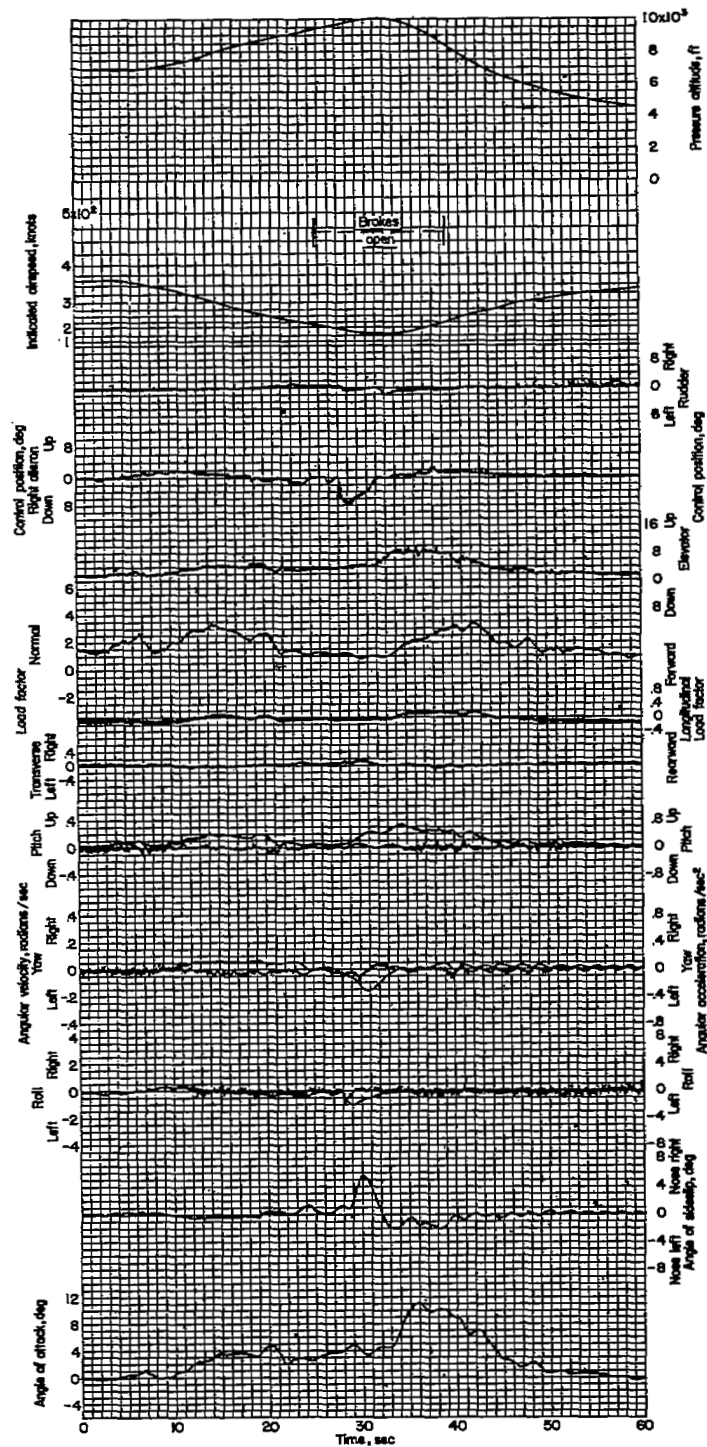


Figure 227.- Split-S. Pilot G; airplane weight, 11,600 pounds; center of gravity at 26.1 percent M.A.C.

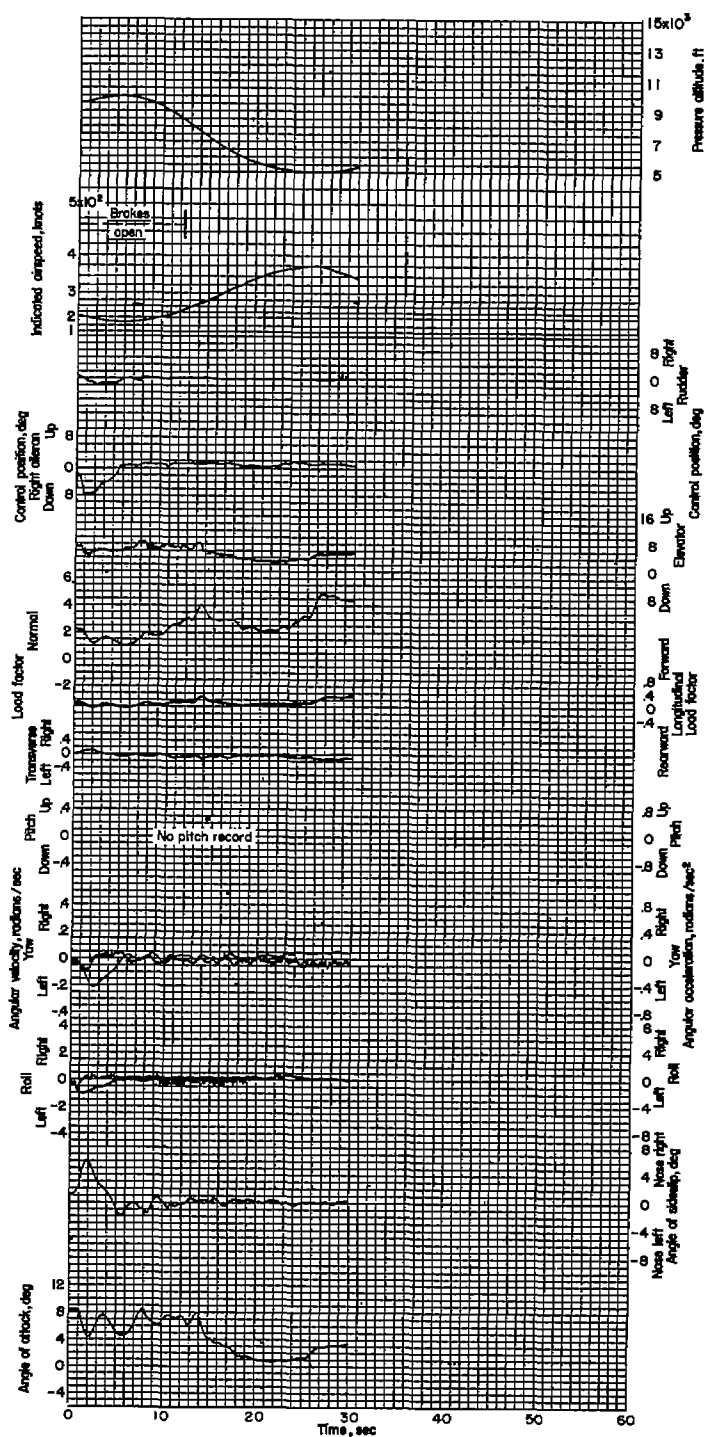


Figure 228.- Split-S. Pilot G with radar observer; airplane weight, 12,210 pounds; center of gravity at 26.0 percent M.A.C.



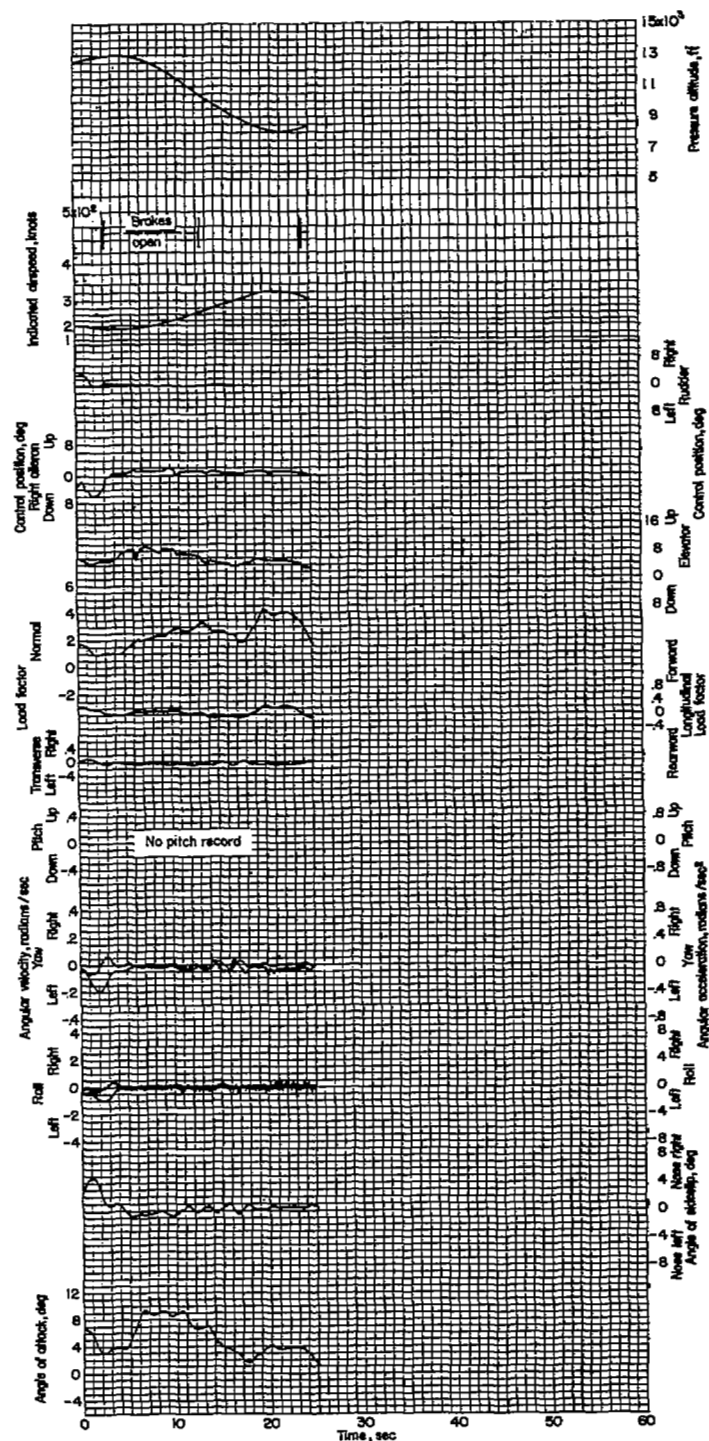


Figure 229.- Split-S. Pilot G with radar observer; airplane weight, 12,260 pounds; center of gravity at 26.1 percent M.A.C.

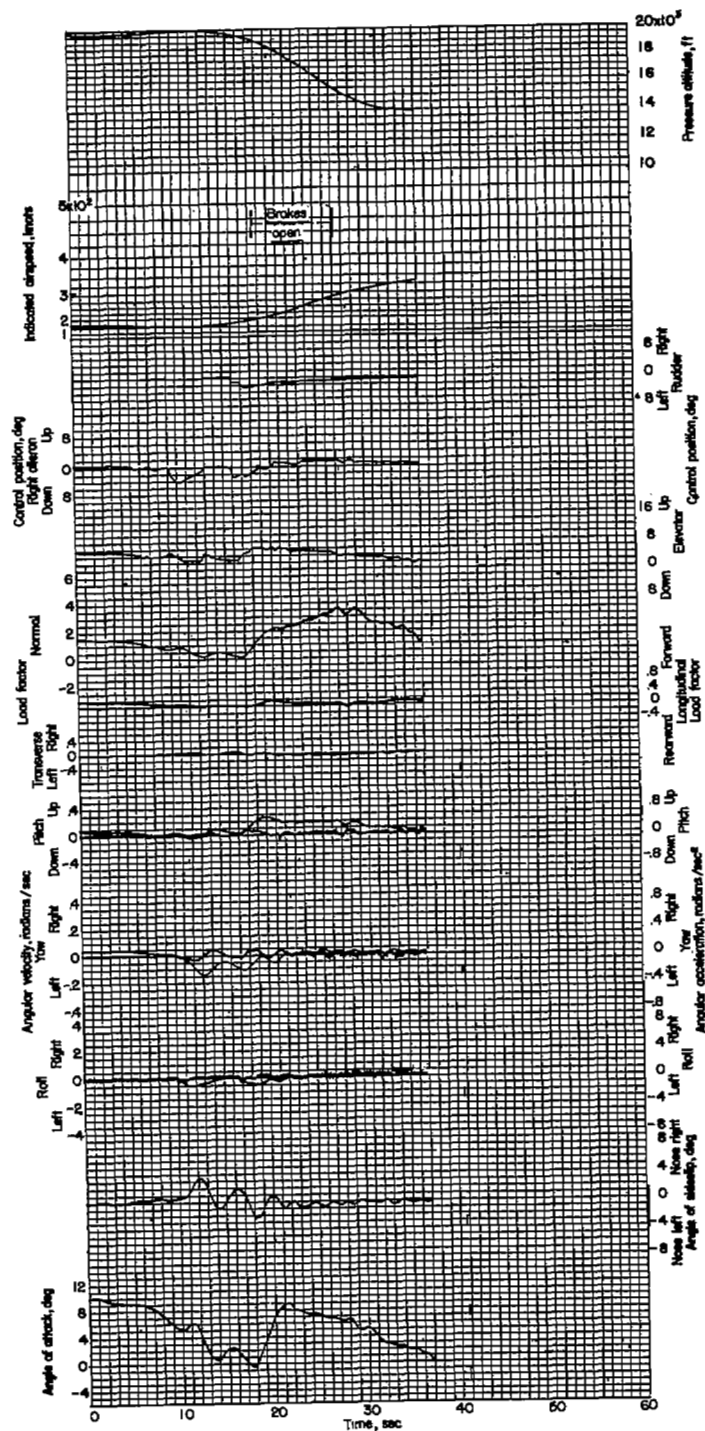


Figure 230.- Split-S. Pilot H with radar observer; airplane weight, 12,430 pounds; center of gravity at 26.4 percent M.A.C.

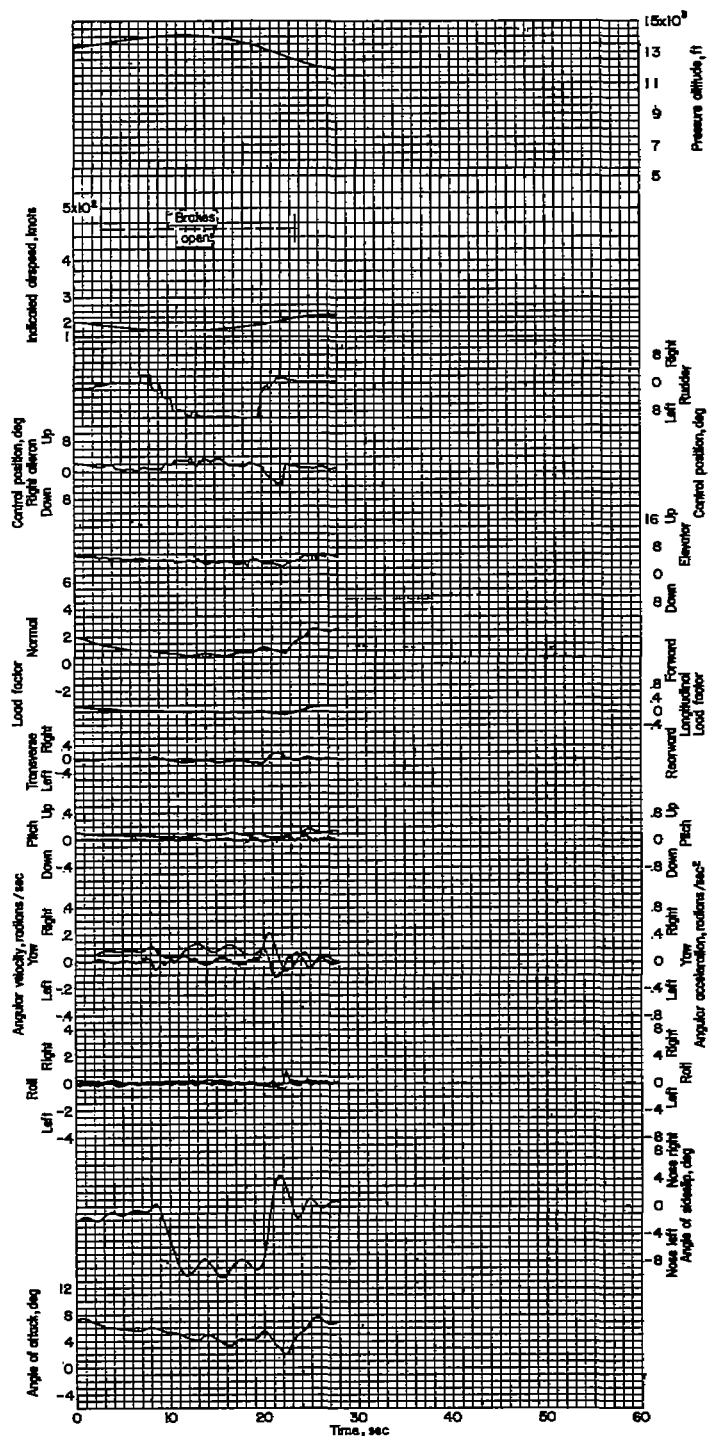


Figure 231.- Right sideslip. Pilot B; airplane weight, 11,910 pounds; center of gravity at 26.7 percent M.A.C.



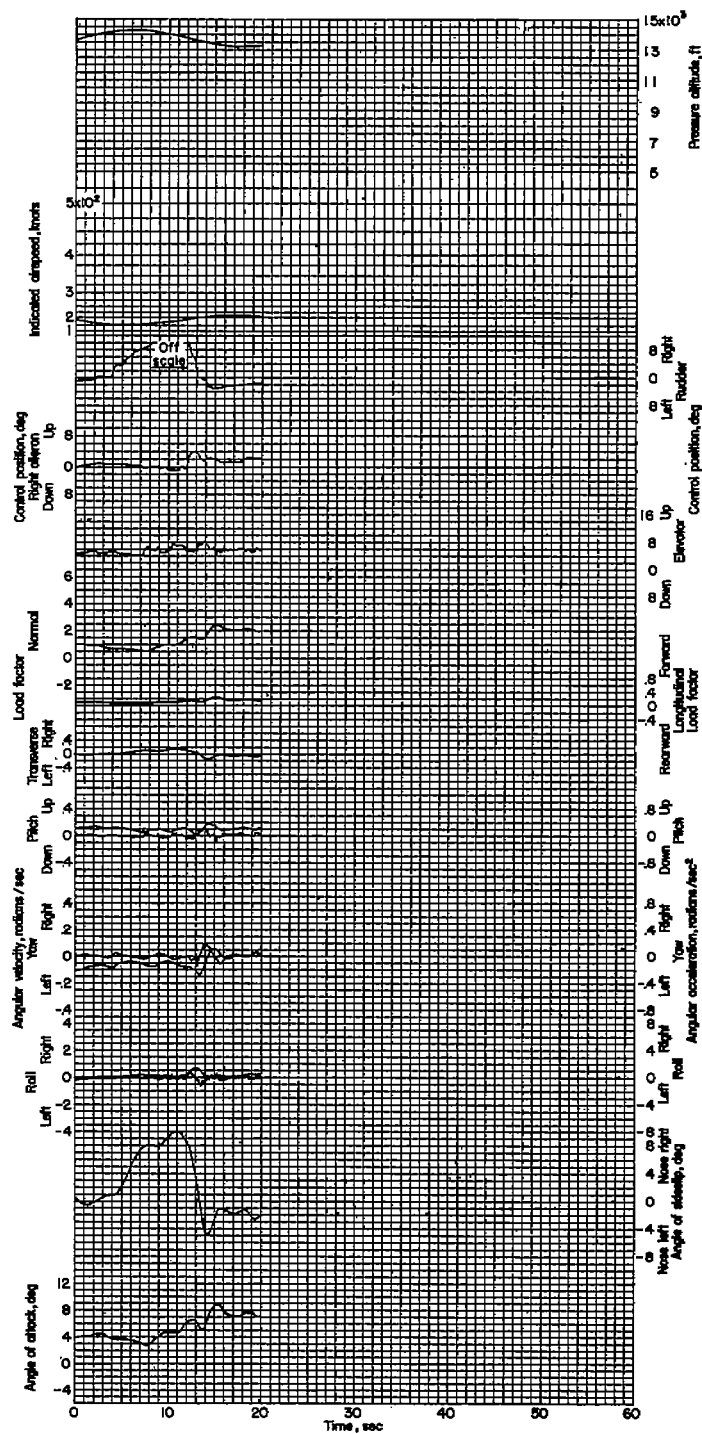


Figure 232.- Left sideslip. Pilot B; airplane weight, 11,935 pounds; center of gravity at 26.8 percent M.A.C.

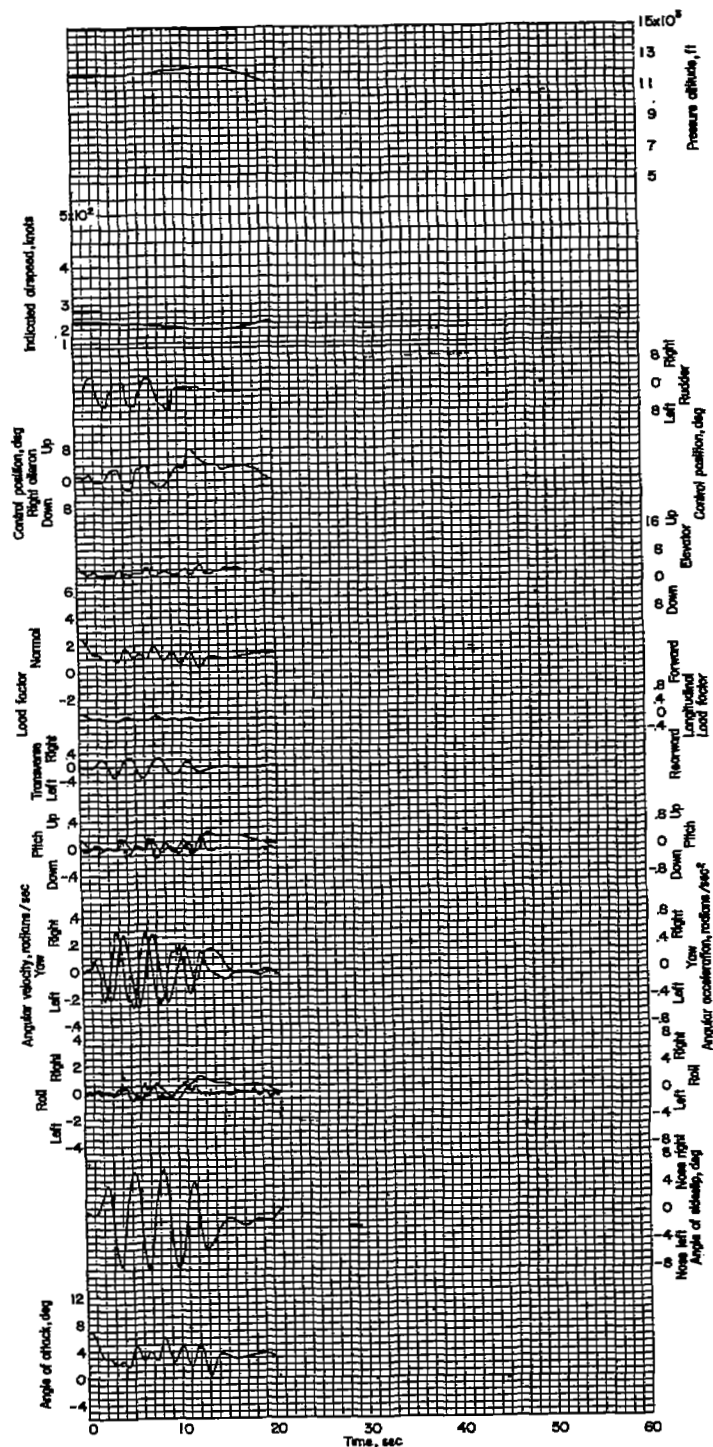


Figure 233.- Rudder kicks. Pilot B; airplane weight, 11,895 pounds; center of gravity at 26.7 percent M.A.C.

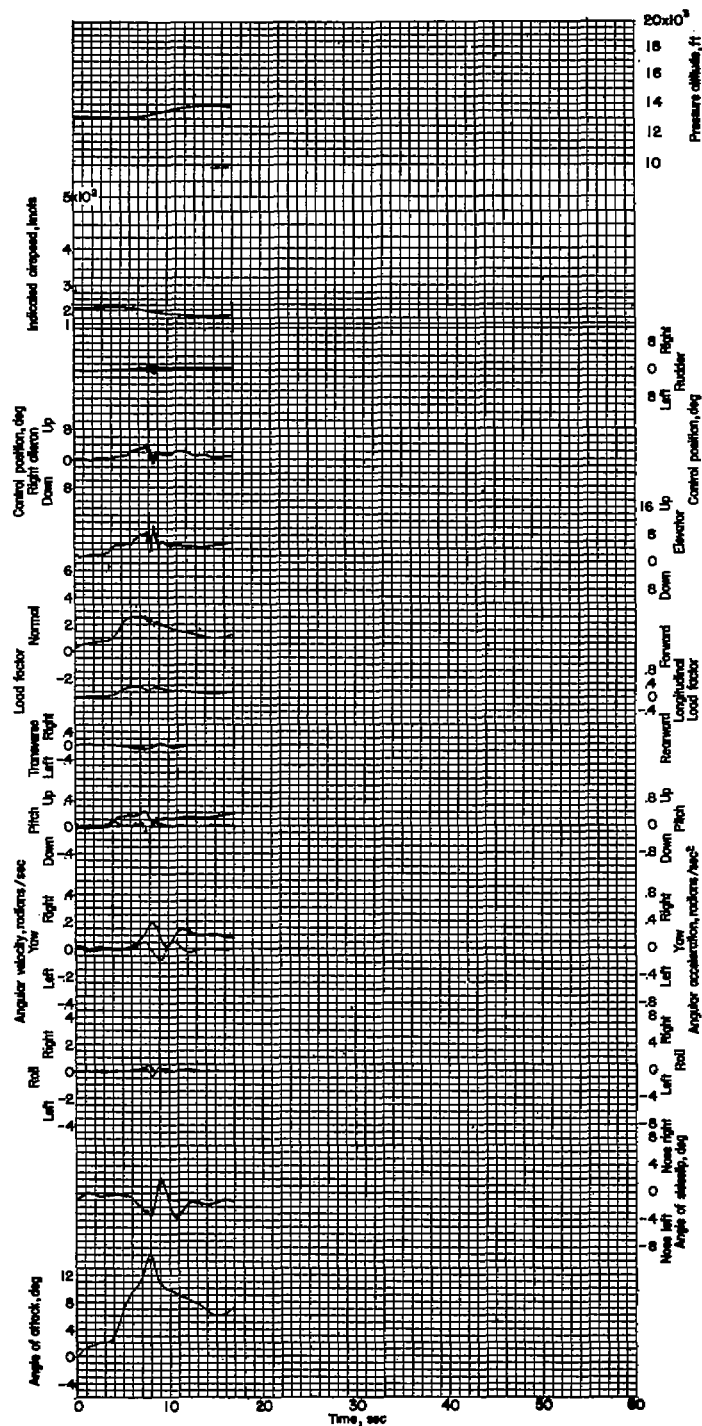
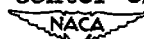


Figure 234.- Stall. Pilot A; airplane weight, 12,080 pounds; center of gravity at 27.0 percent M.A.C.



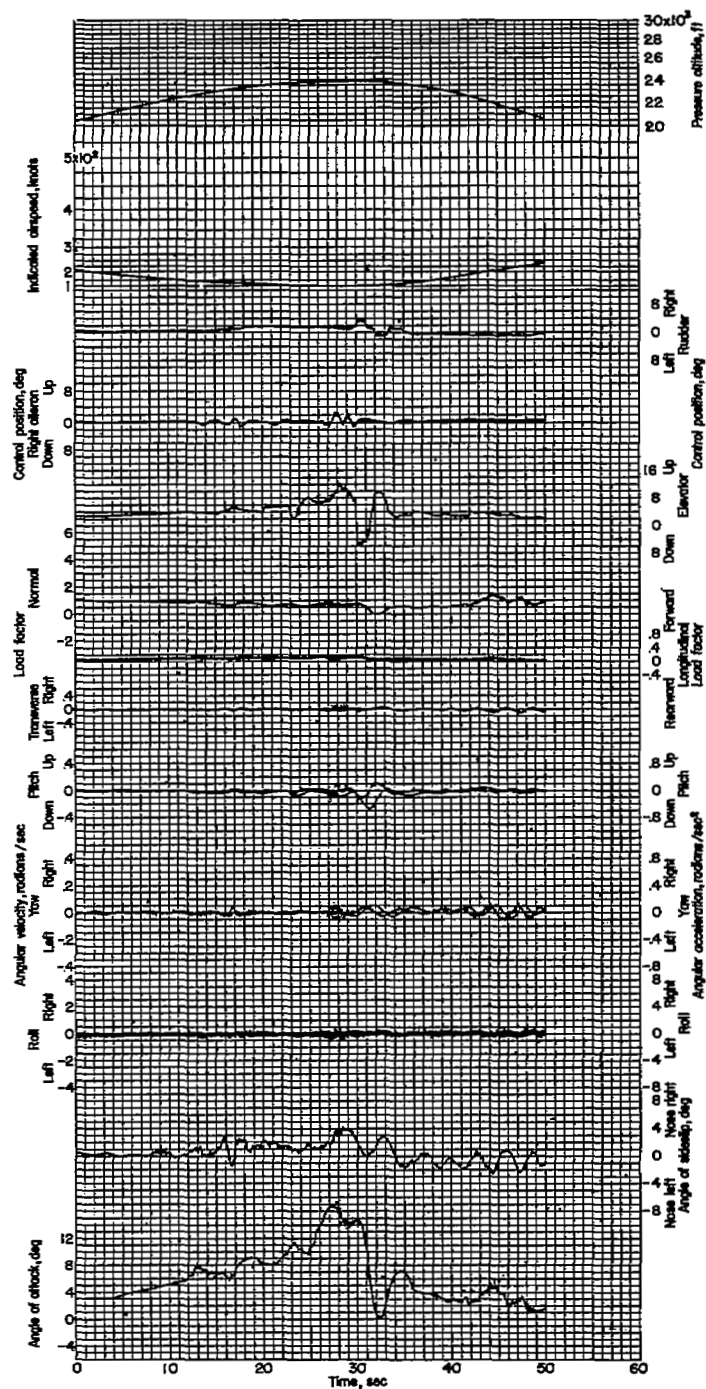


Figure 235.- Stall. Pilot A; airplane weight, 11,900 pounds; center of gravity at 26.7 percent M.A.C.

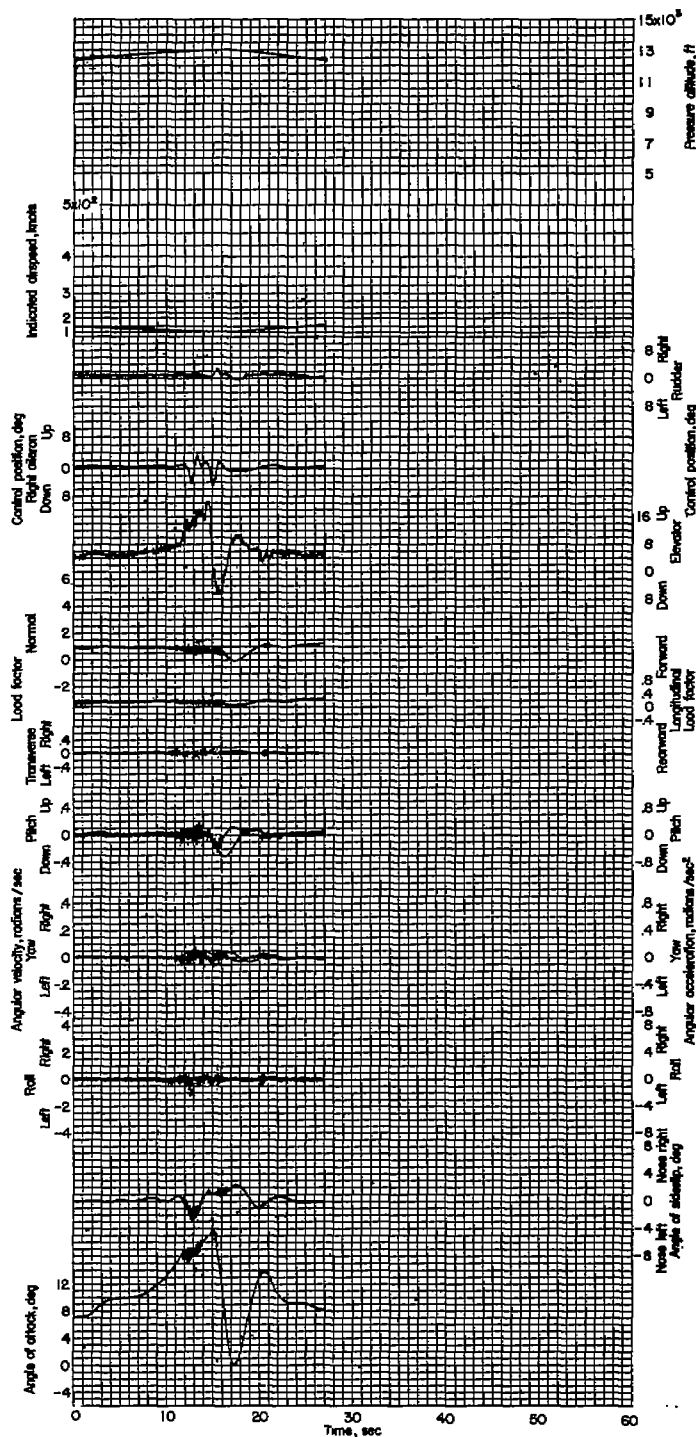


Figure 236.- Stall. Pilot A wearing anti-gravity suit; airplane weight, 11,990 pounds; center of gravity at 26.8 percent M.A.C.

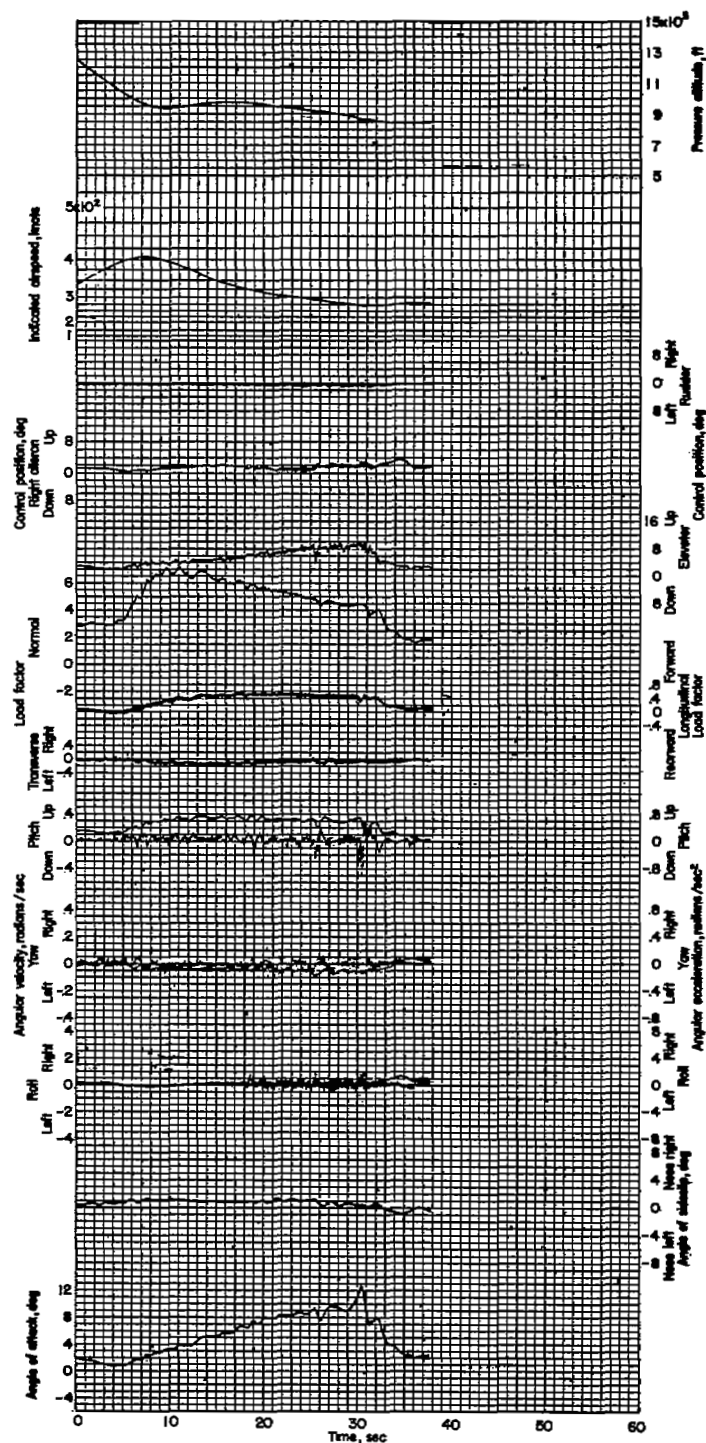


Figure 237.- Stall. Pilot B; airplane weight, 12,025 pounds; center of gravity at 26.9 percent M.A.C.

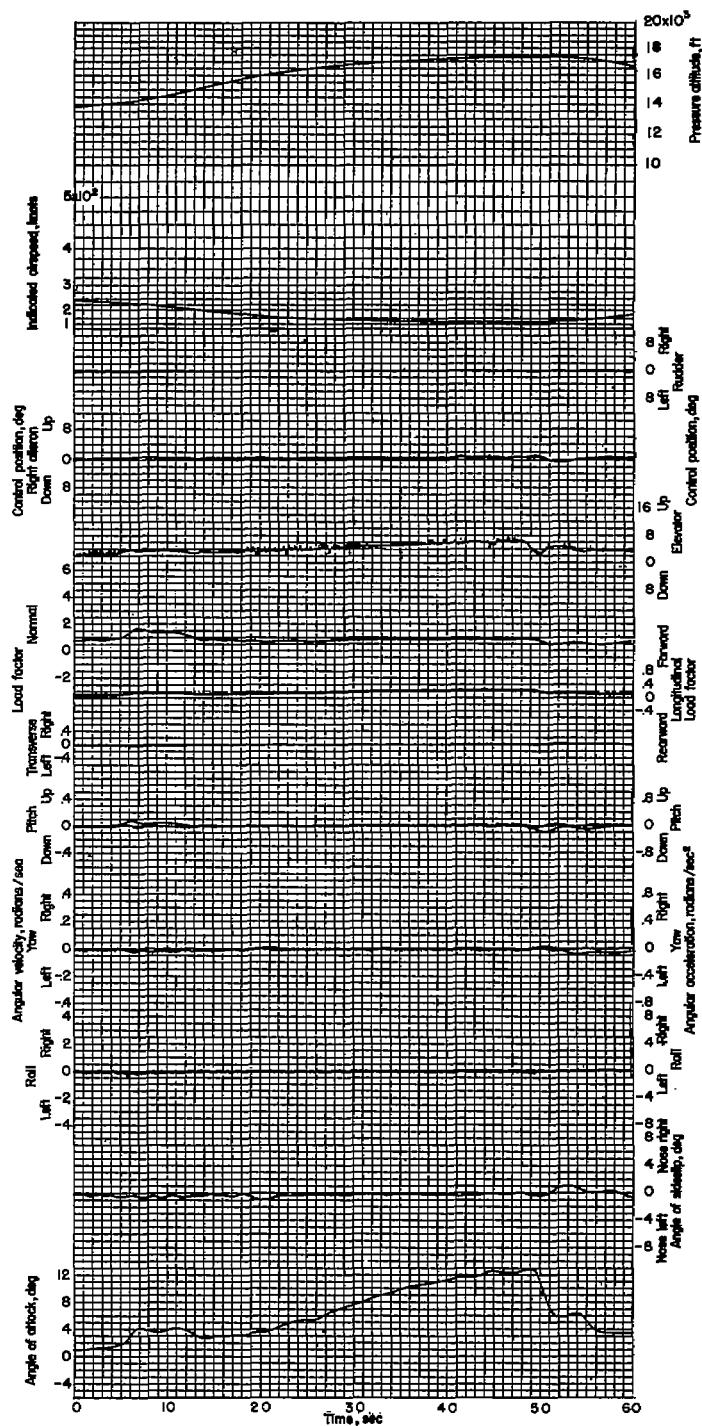


Figure 238.- Stall. Pilot F wearing anti-gravity suit; airplane weight, 12,620 pounds; center of gravity at 27.7 percent M.A.C.

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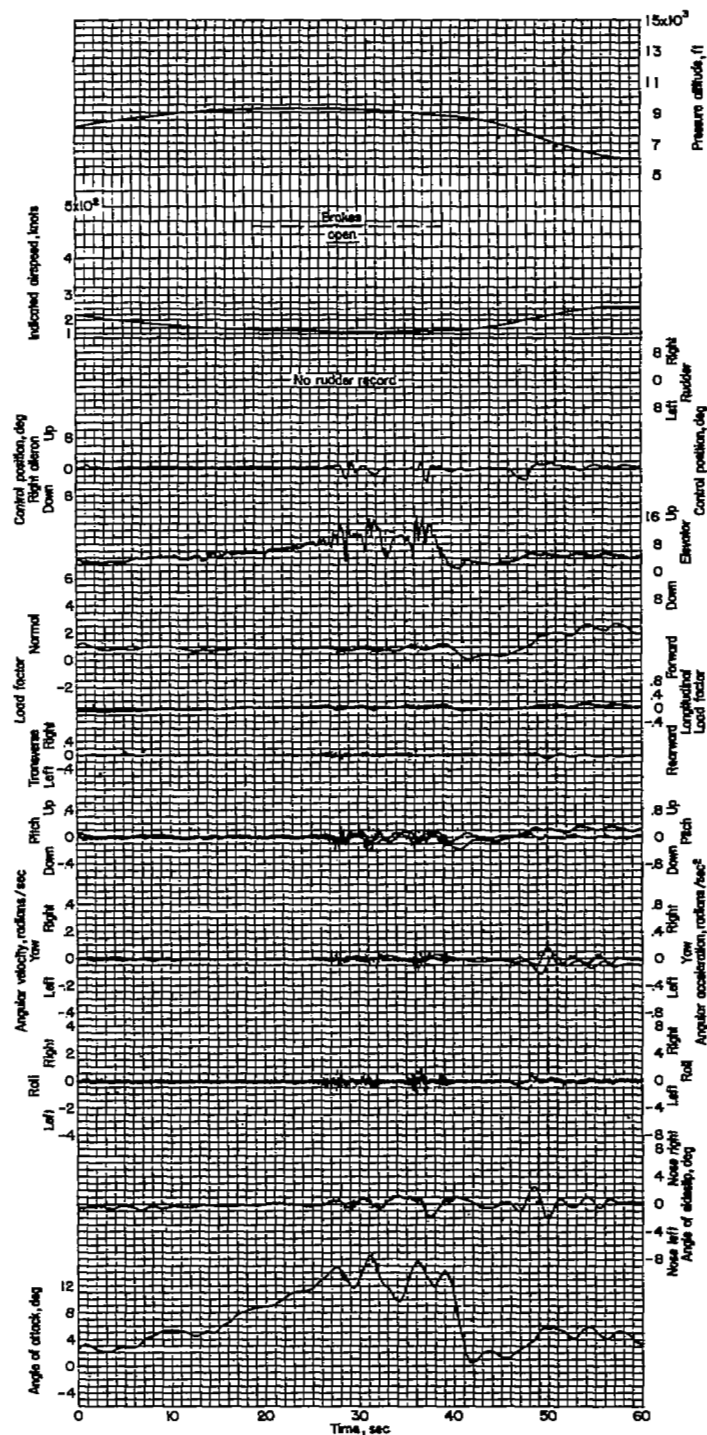


Figure 239.- Stall. Pilot G; airplane weight, 12,170 pounds; center of gravity at 27.2 percent M.A.C.

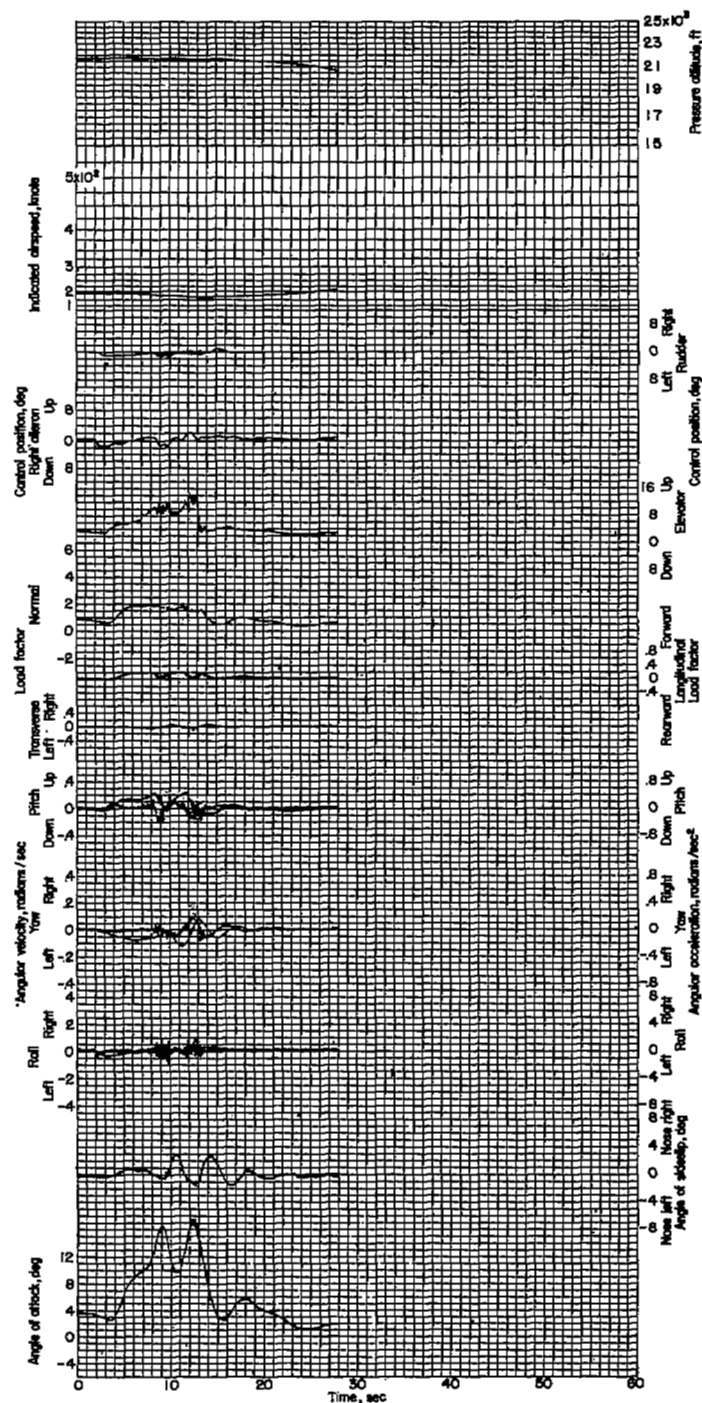


Figure 240.- Stall. Pilot H with radar observer; airplane weight, 12,610 pounds; center of gravity at 26.8 percent M.A.C.



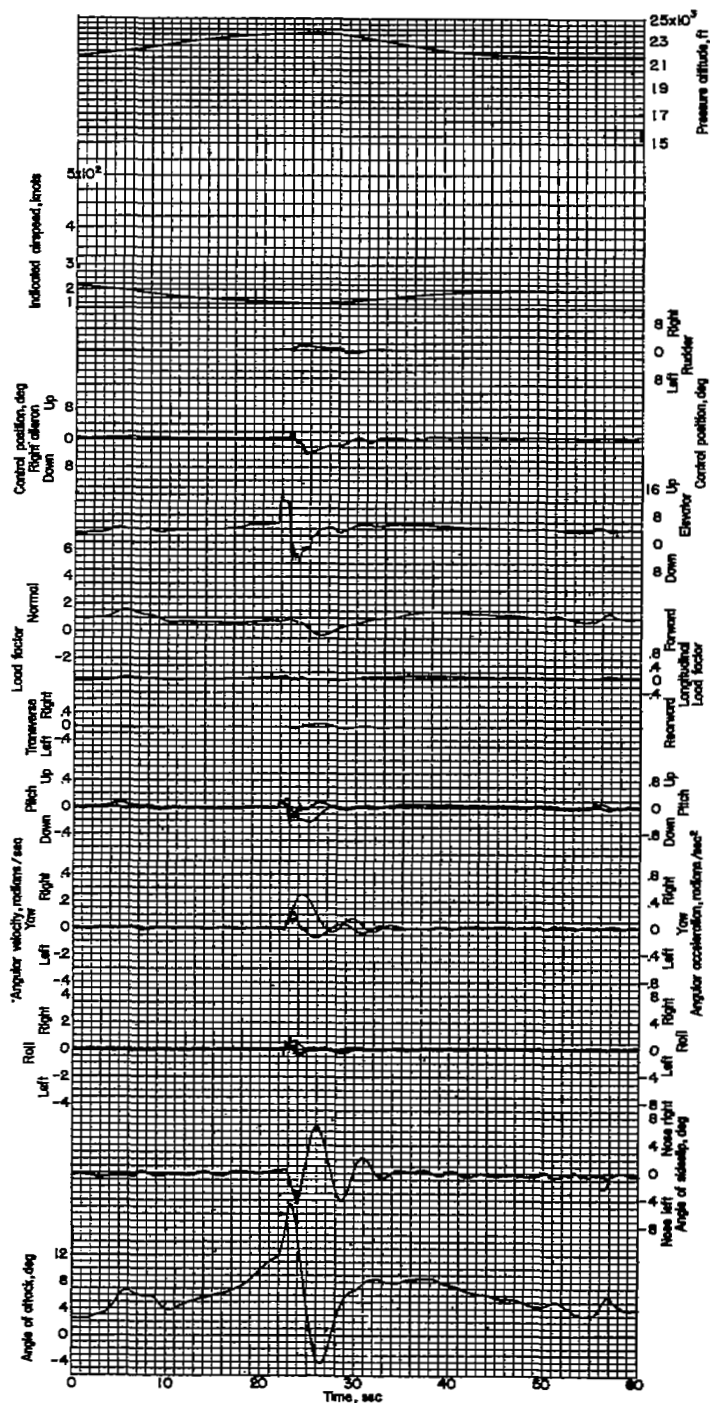
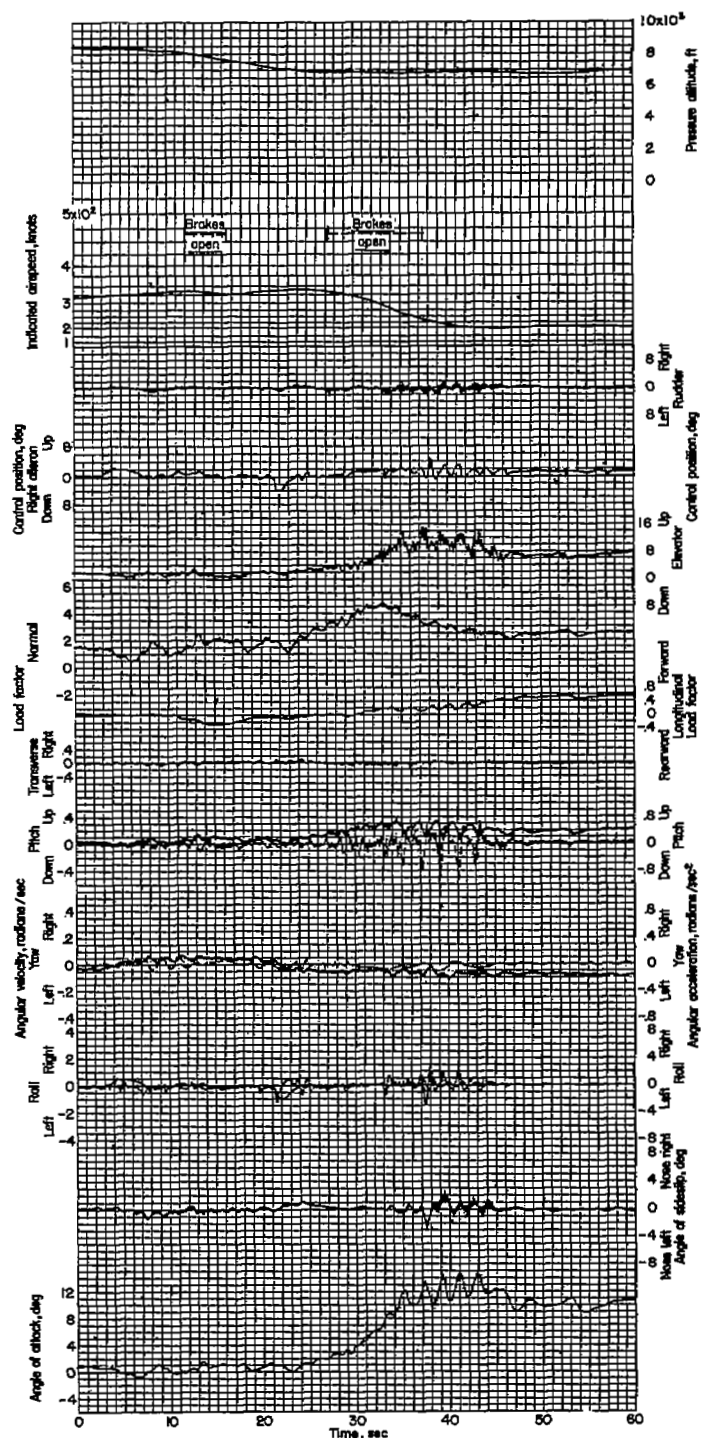


Figure 241.- Stall. Pilot H with radar observer; airplane weight, 12,650 pounds; center of gravity at 26.8 percent M.A.C.

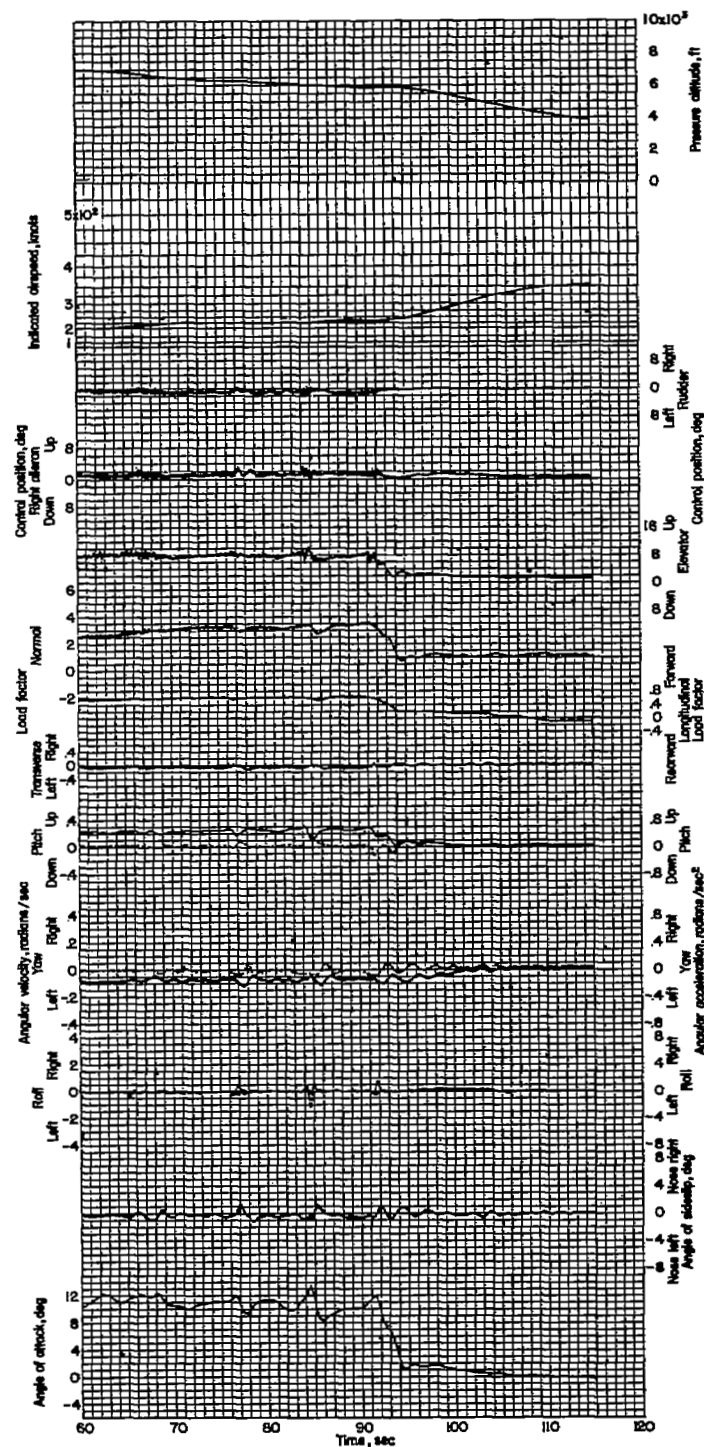
NACA



(a)



Figure 242.- Stall during left turn. Pilot A; airplane weight, 11,950 pounds; center of gravity at 26.8 percent M.A.C.



(b)



Figure 242.- Concluded.

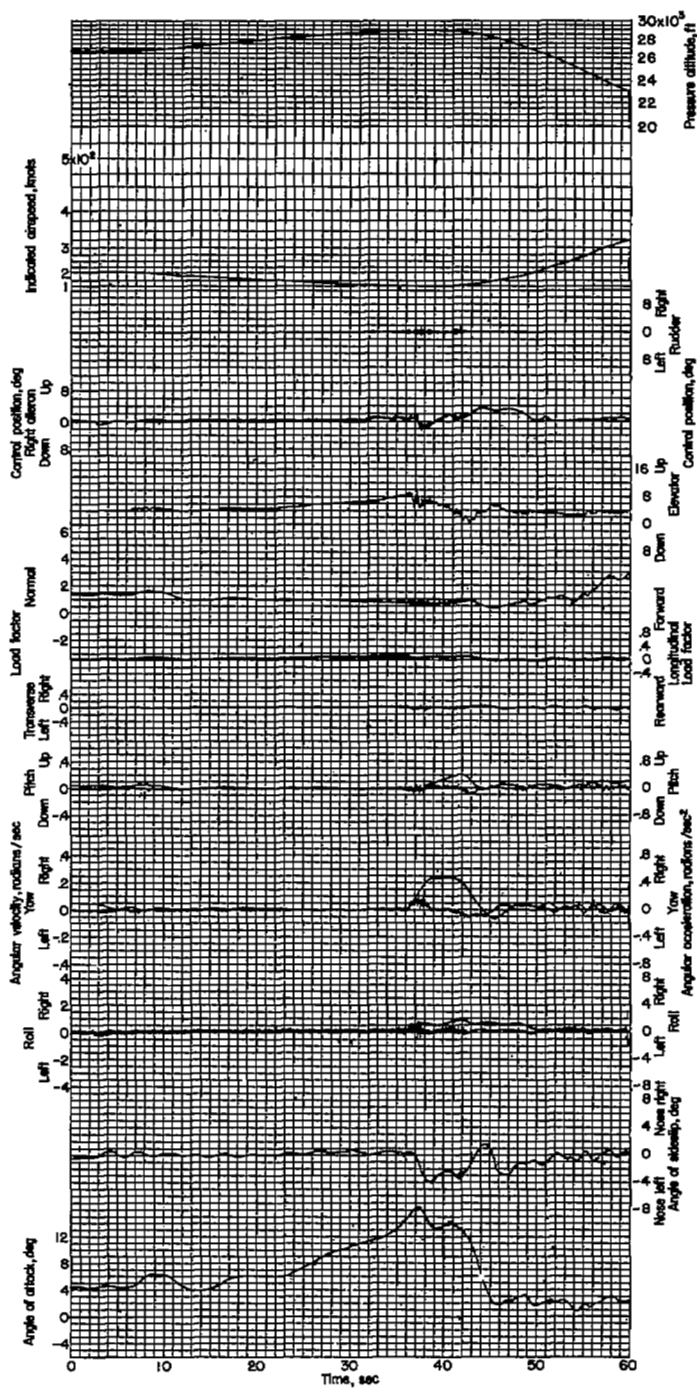


Figure 243.- Stall with right rolling recovery. Pilot B; airplane weight, 12,110 pounds; center of gravity at 27.1 percent M.A.C.

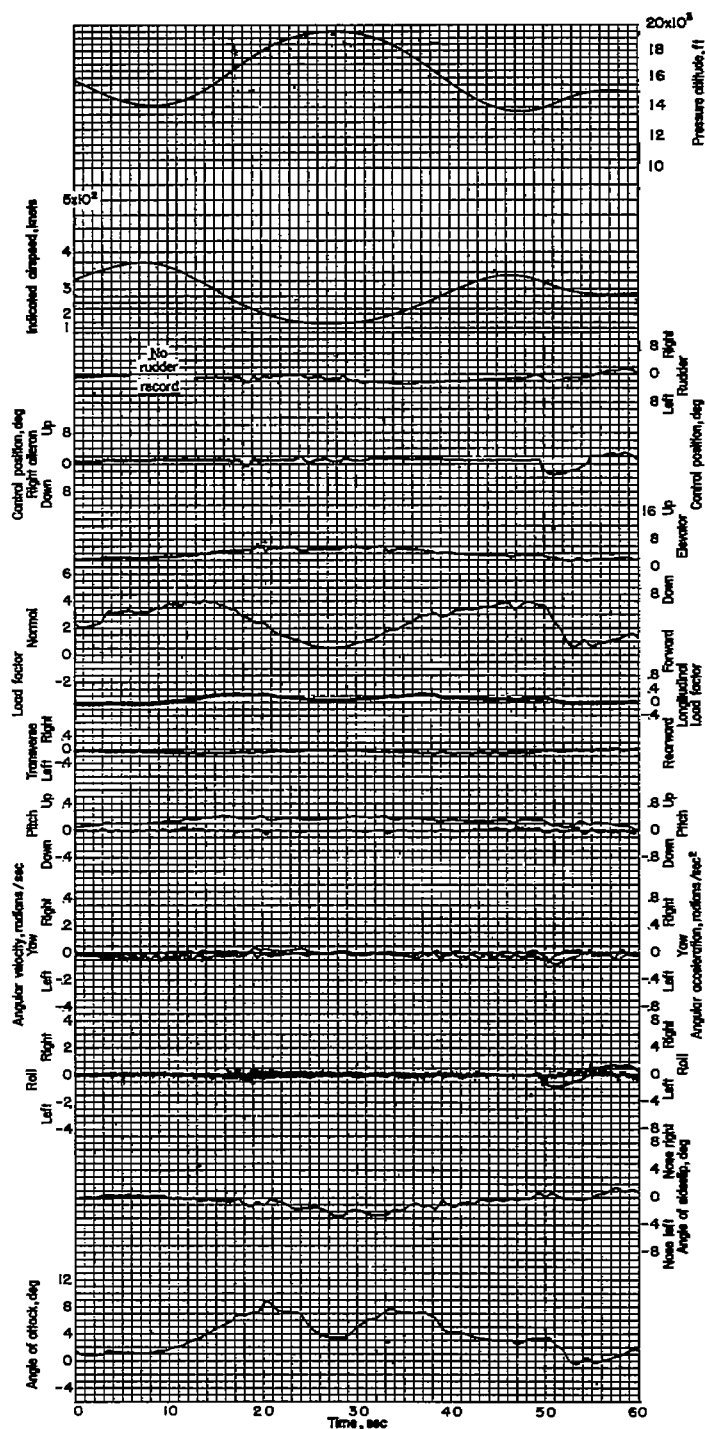
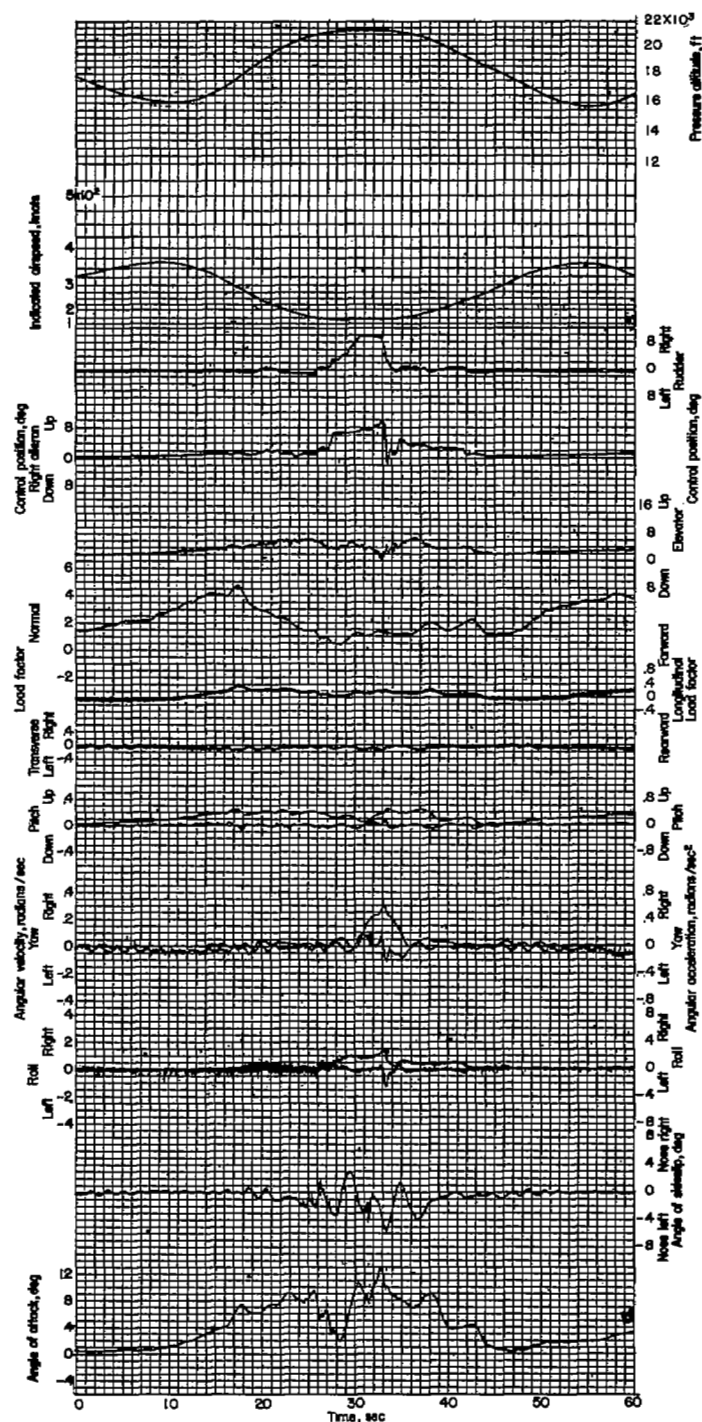


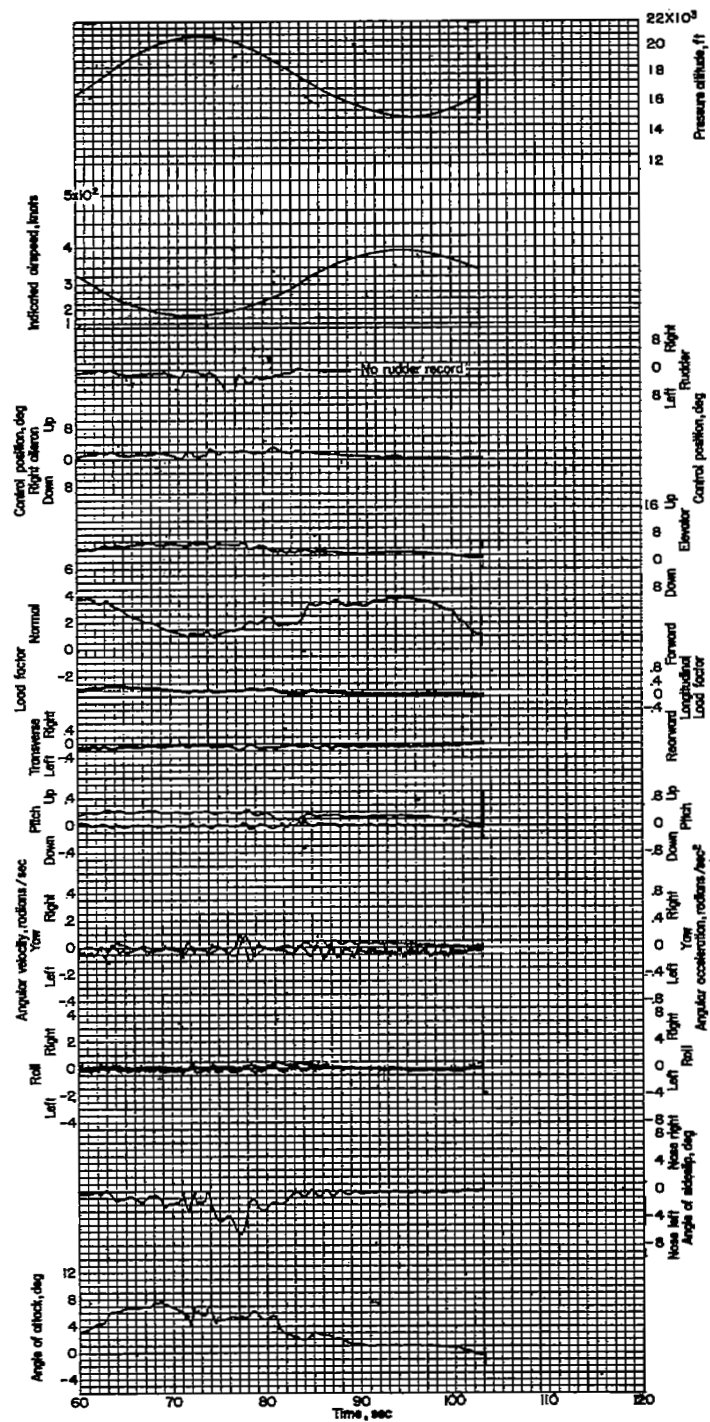
Figure 244.- Loop followed by a vertical recovery. Pilot A; airplane weight, 11,680 pounds; center of gravity at 26.2 percent M.A.C.



(a)



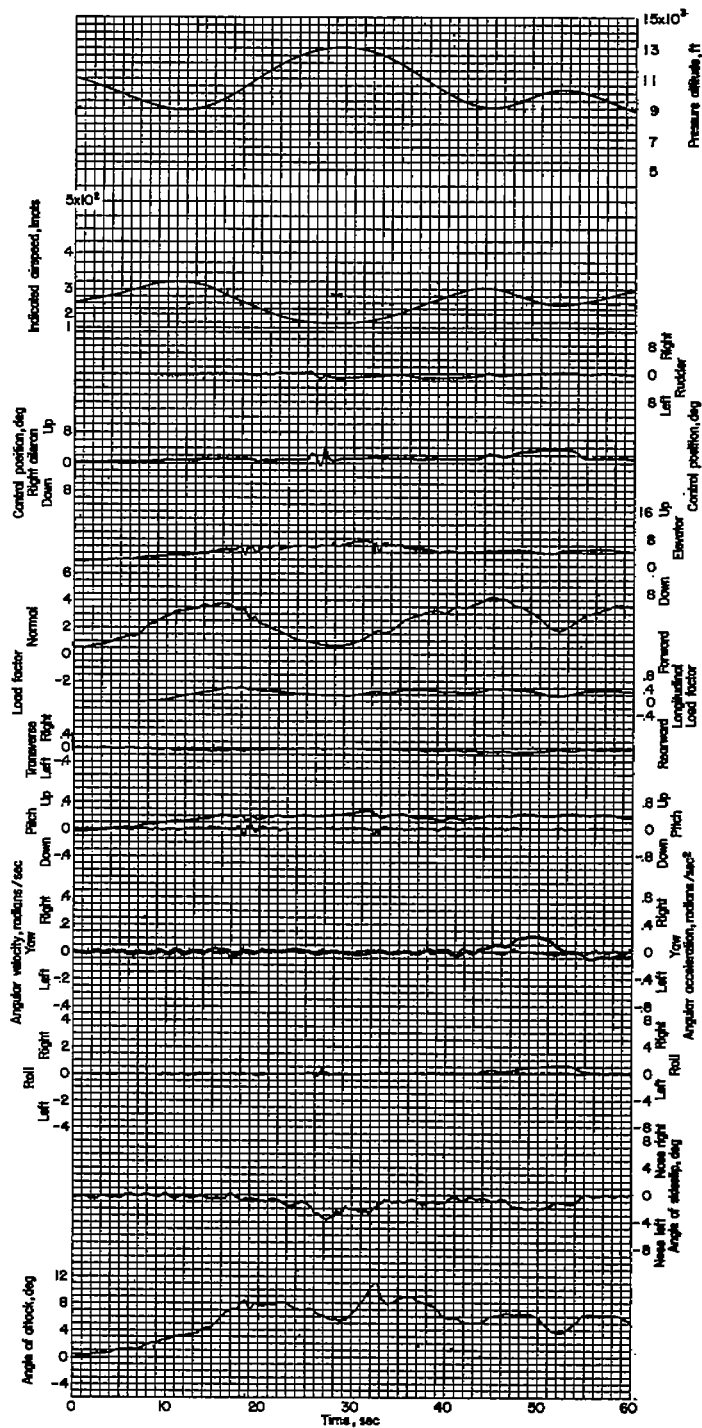
Figure 245.- Loop with right aileron roll on top and right half-roll recovery followed by a loop. Pilot A; airplane weight, 11,830 pounds; center of gravity at 26.5 percent M.A.C.



(b)

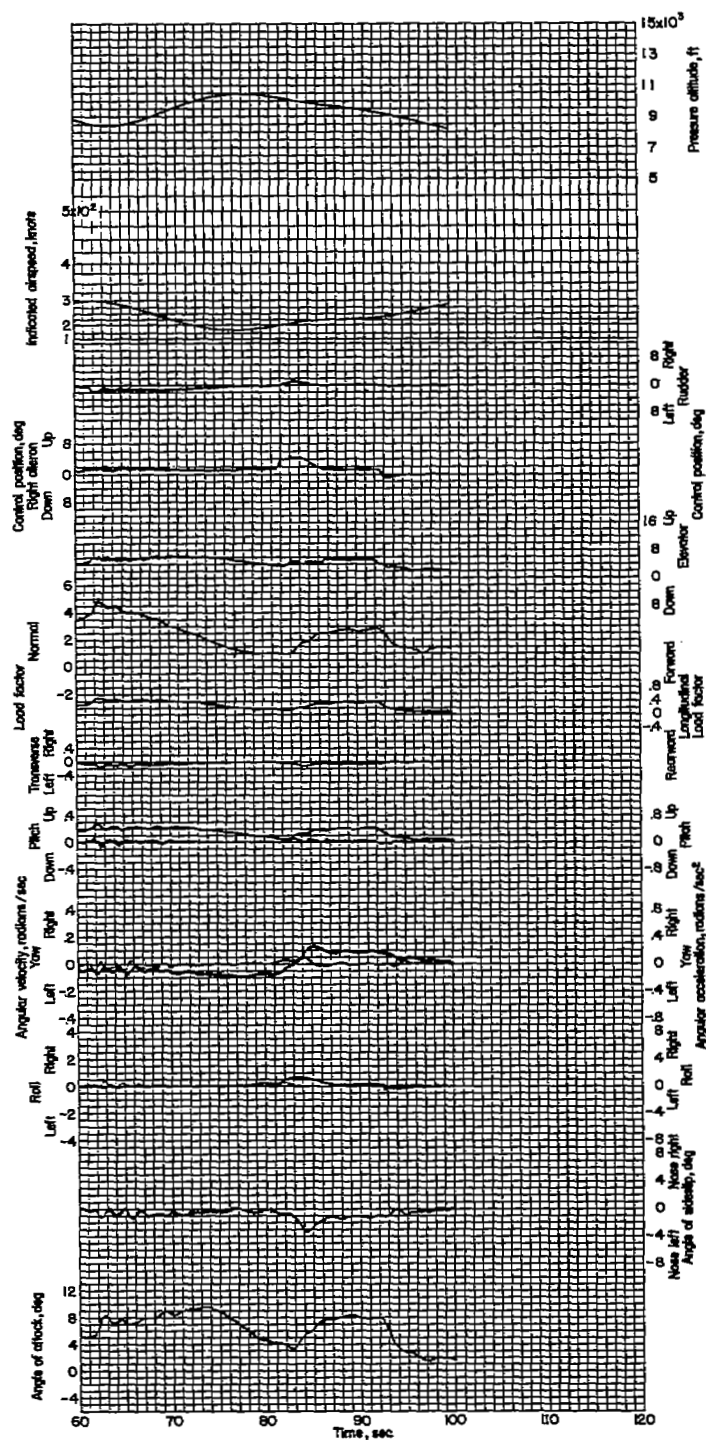


Figure 245.- Concluded.



(a)

Figure 246.- Loop followed by right three-quarter aileron roll into a chandelle. Pilot A; airplane weight, 12,040 pounds; center of gravity at 27.0 percent M.A.C.



(b)



Figure 246.- Concluded.

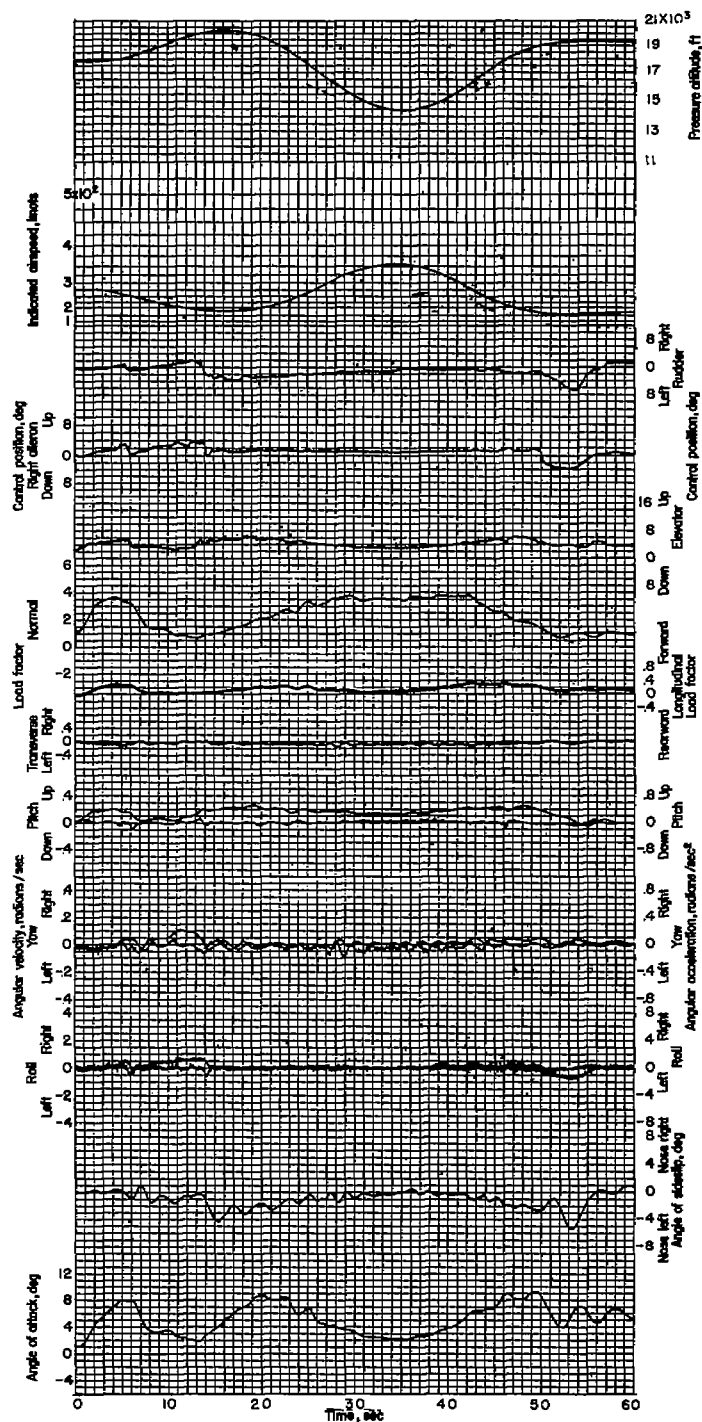


Figure 247.- Split-S into an Immelman. Pilot A; airplane weight, 12,040 pounds; center of gravity at 27.0 percent M.A.C.

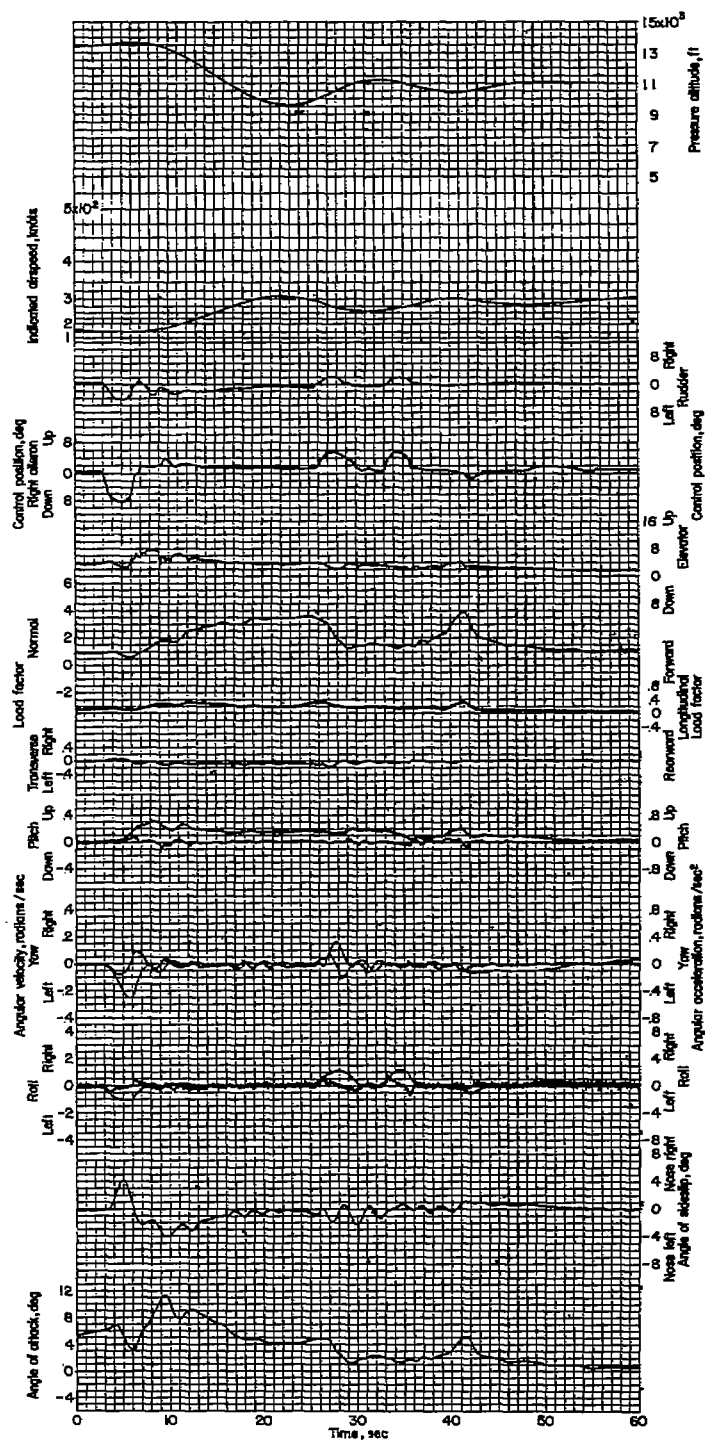


Figure 248.- Split-S into a vertical recovery. Pilot A wearing anti-gravity suit; airplane weight, 12,220 pounds; center of gravity at 27.3 percent M.A.C.

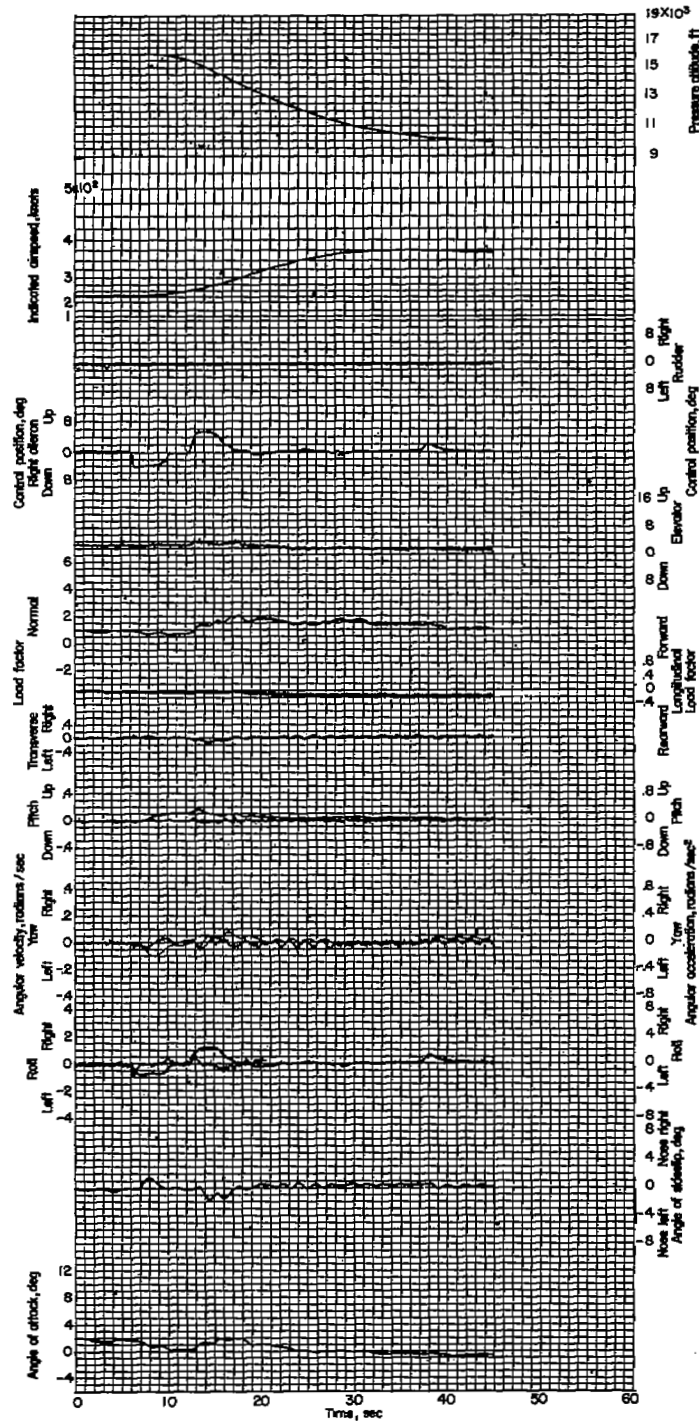


Figure 249.- Left roll entry into a dive with right half-roll and normal pull-out. Pilot B; airplane weight, 11,830 pounds; center of gravity at 26.6 percent M.A.C.

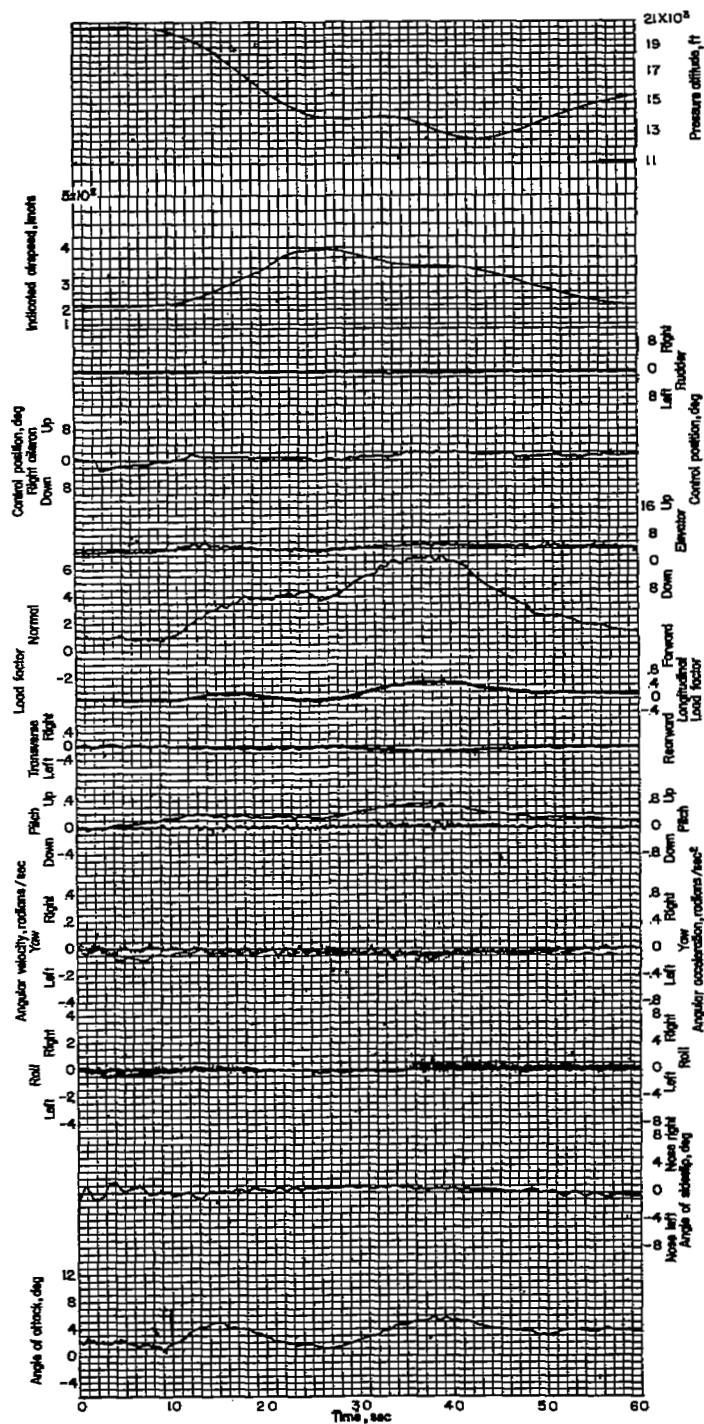
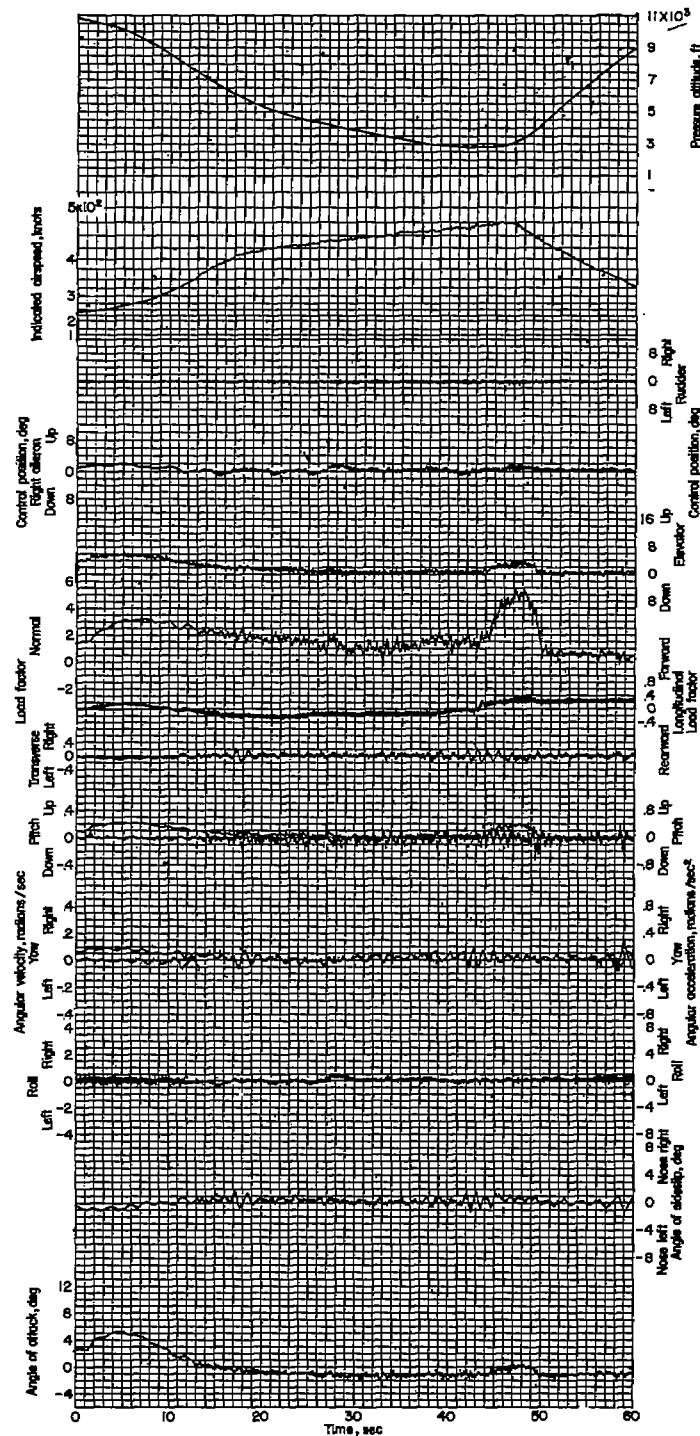


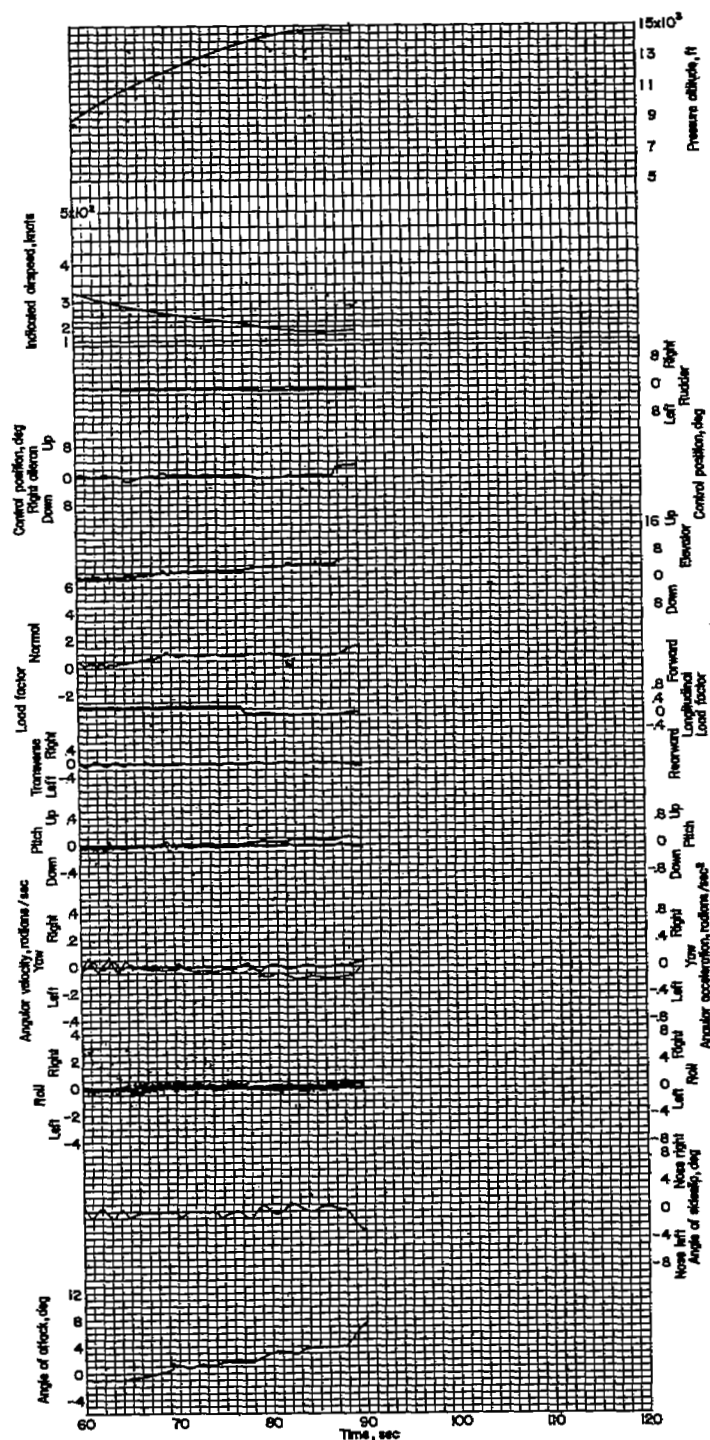
Figure 250.- Left roll entry into a dive followed by diving left turn into a climb. Pilot B; airplane weight, 11,900 pounds; center of gravity at 26.7 percent M.A.C.



(a)



Figure 251.- Dive with sharp pull-up into a chandelle. Pilot B; airplane weight, 11,740 pounds; center of gravity at 26.4 per cent M.A.C.



(b)



Figure 251.- Concluded.

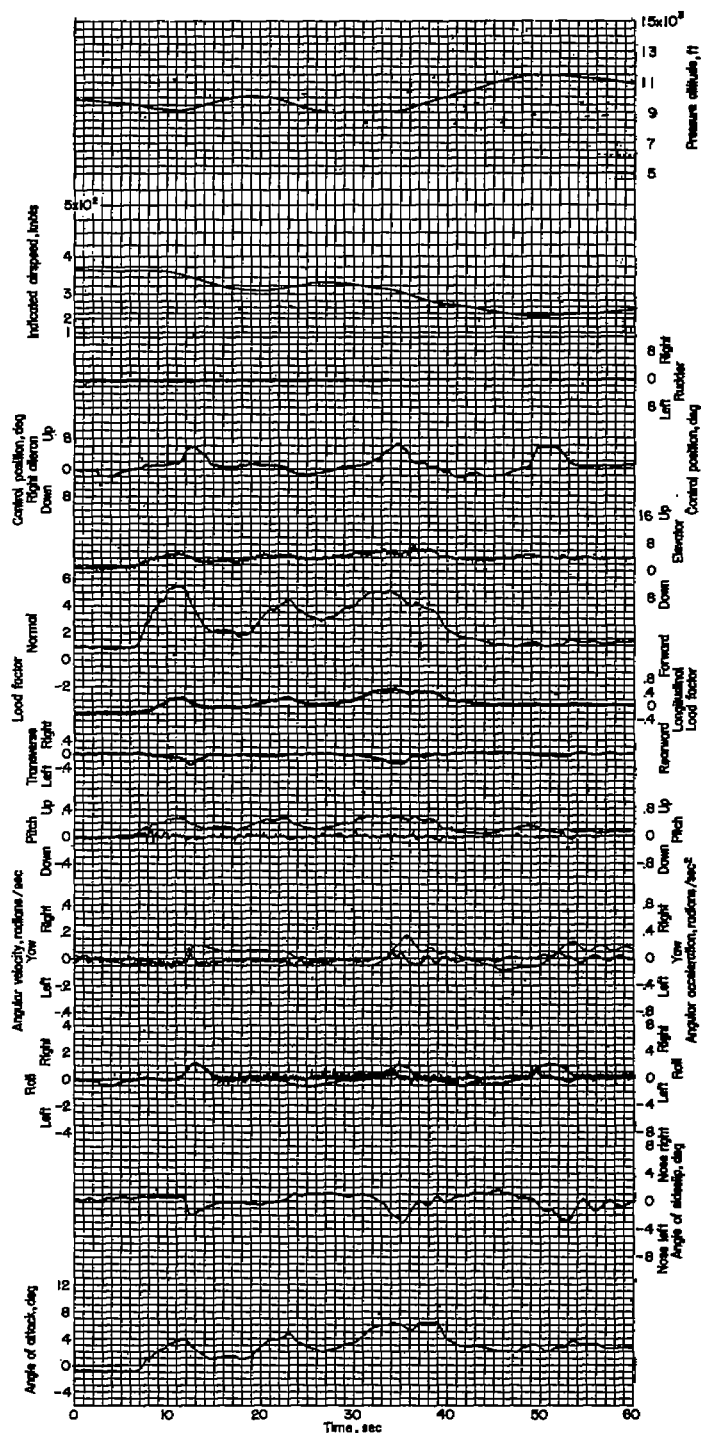


Figure 252.- Wing-over followed by chandelle. Pilot B; airplane weight, 11,790 pounds; center of gravity 26.5 percent M.A.C.

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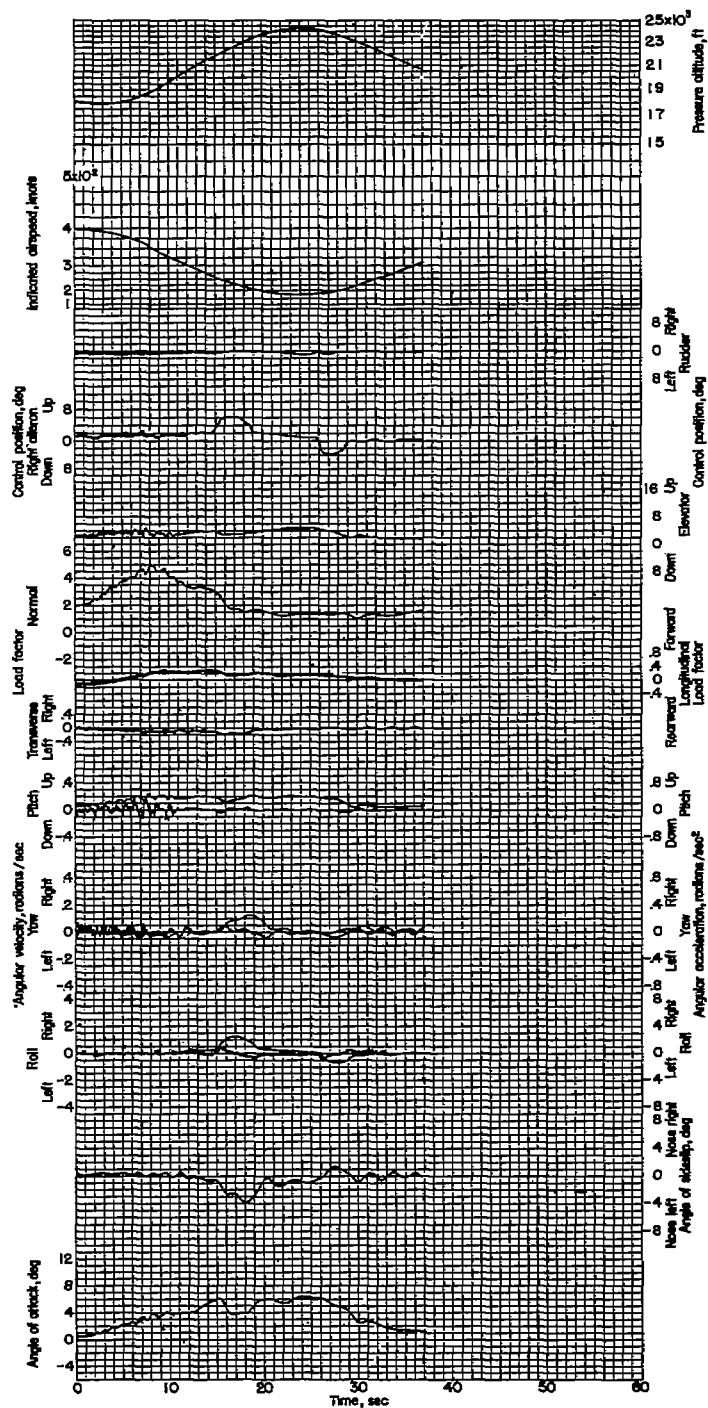


Figure 253.- Loop with right aileron roll and quarter-roll recovery.
 Pilot B; airplane weight, 12,200 pounds; center of gravity at
 27.3 percent M.A.C.

NACA

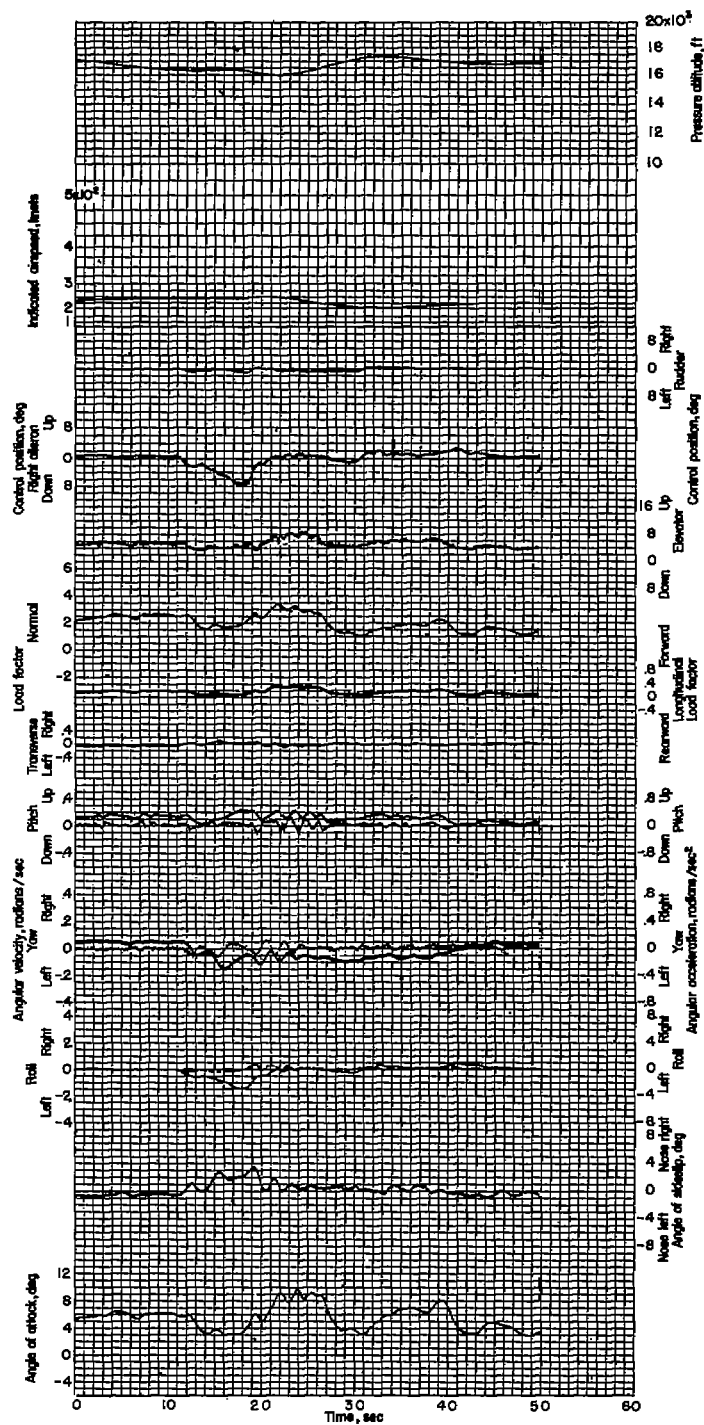
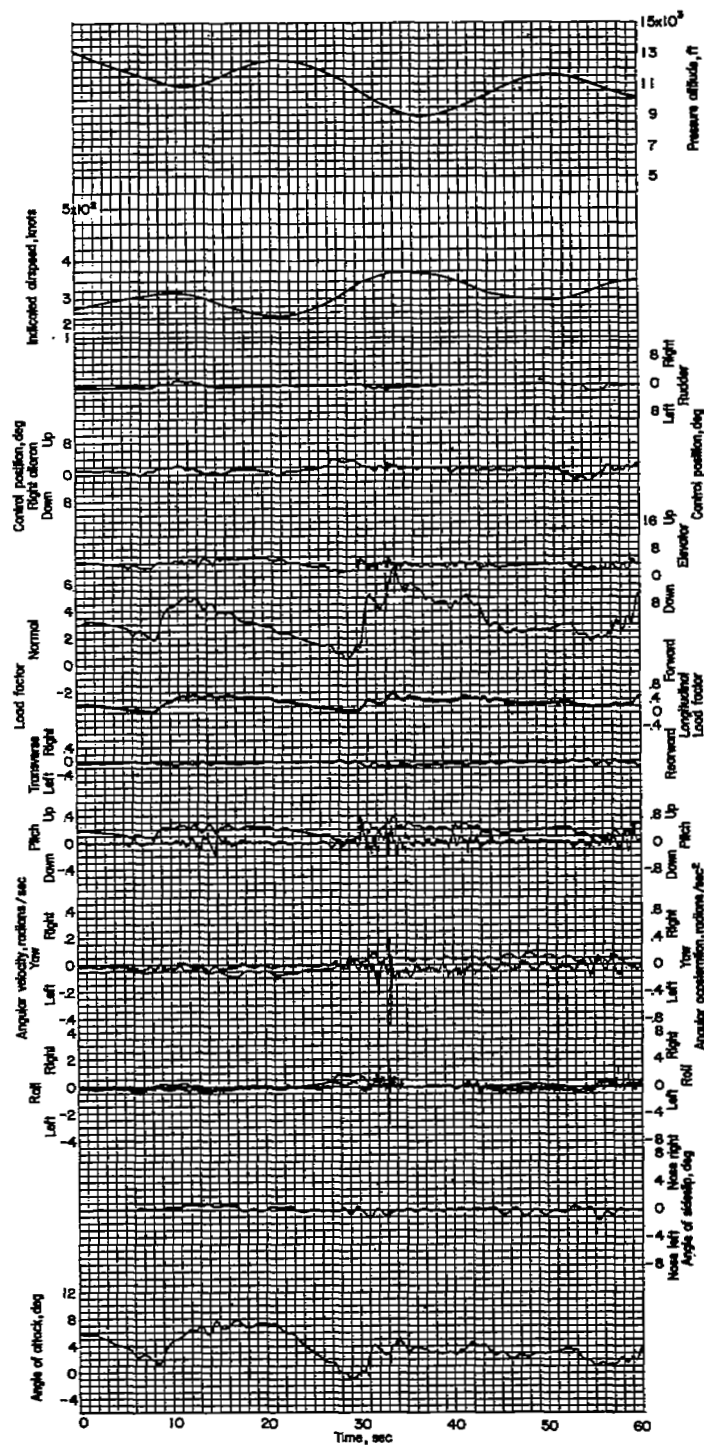


Figure 254.- Left aileron roll followed by a chandelle. Pilot C with radar observer; airplane weight, 12,200 pounds; center of gravity at 25.9 percent M.A.C.

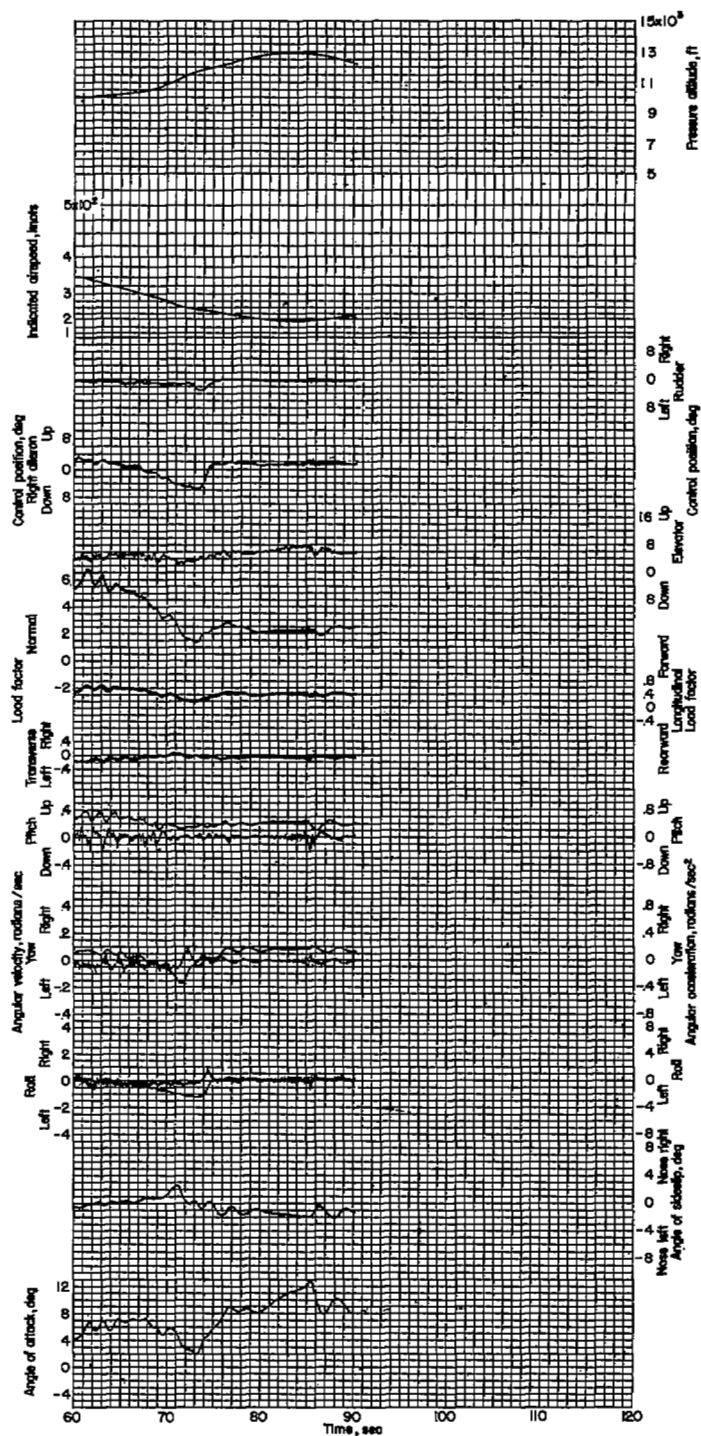
NACA



(a)



Figure 255.- Lazy eight followed by right aileron roll. Pilot F wearing anti-gravity suit; airplane weight, 12,410 pounds; center of gravity at 27.7 percent M.A.C.



(b)



Figure 255.- Concluded.

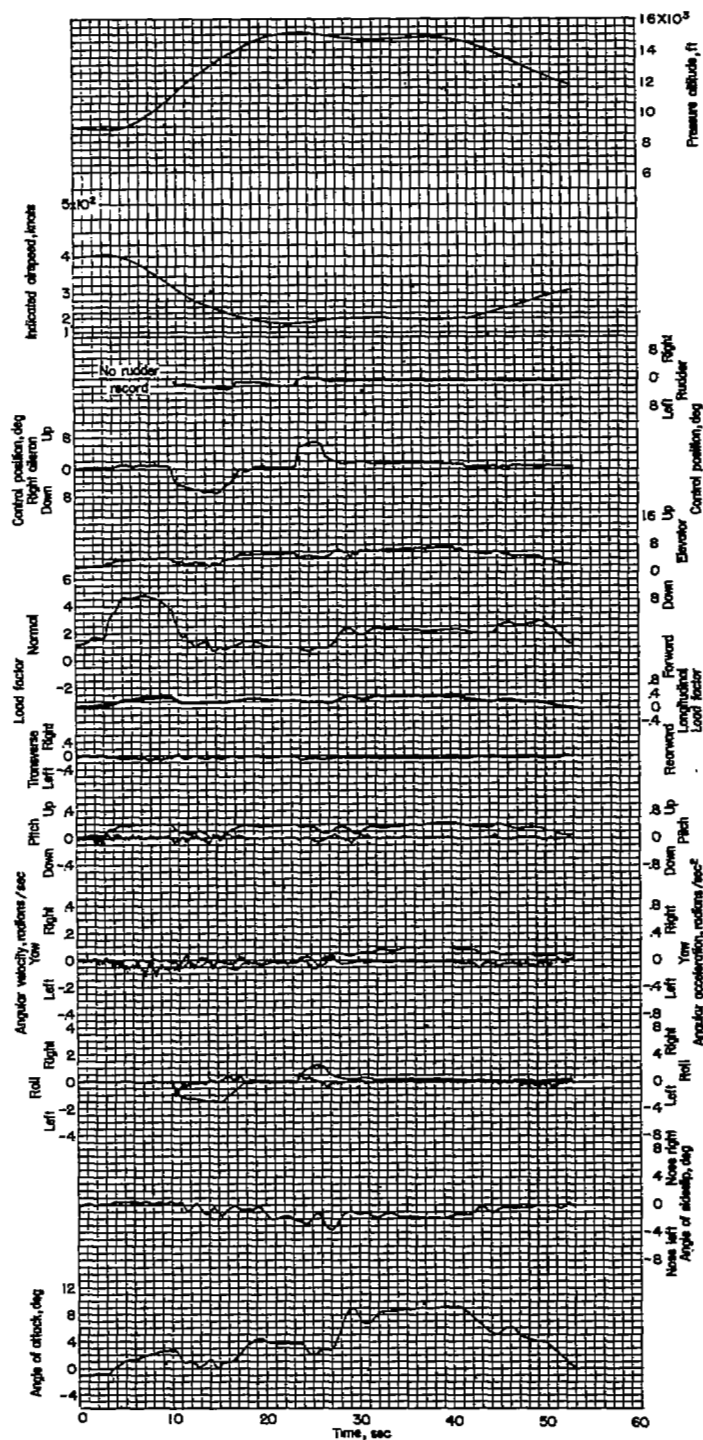


Figure 256.- Immelman with left aileron roll. Pilot F wearing anti-gravity suit; airplane weight, 11,660 pounds; center of gravity at 26.2 percent M.A.C.

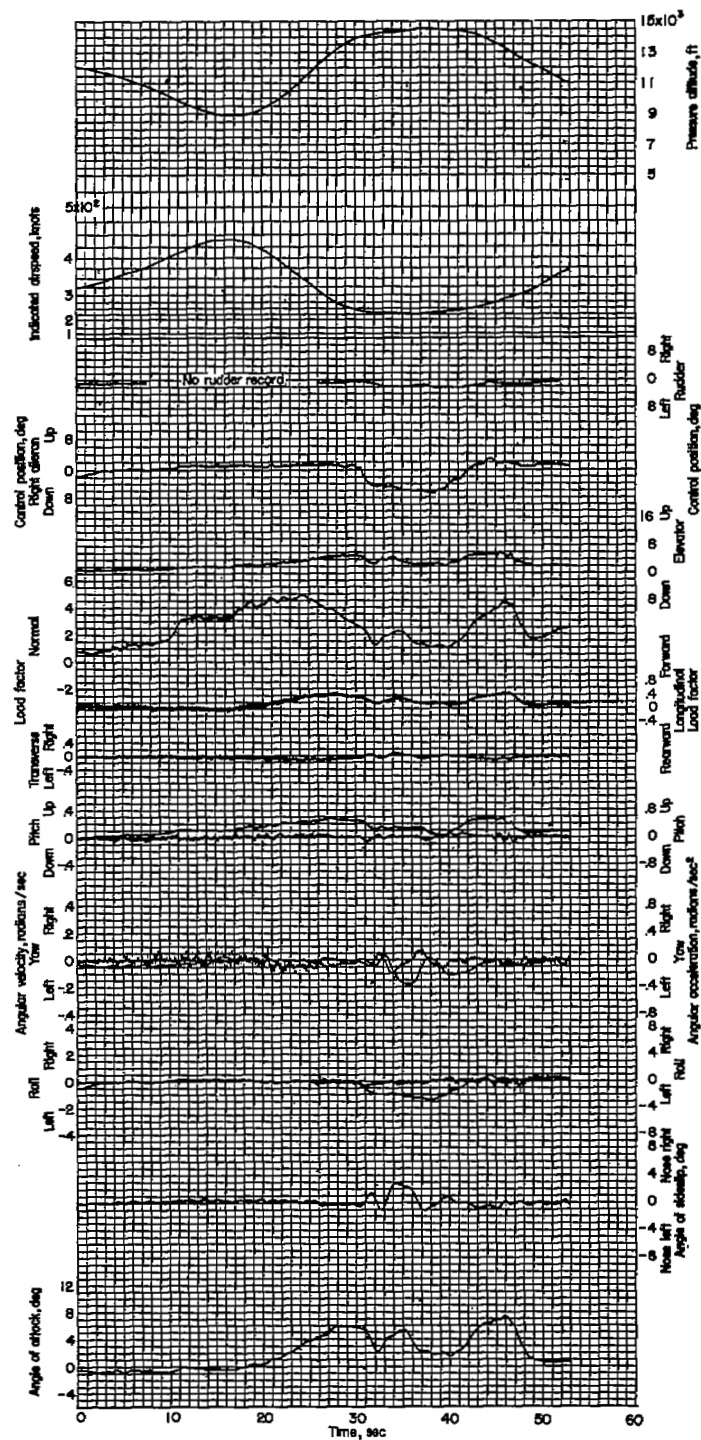


Figure 257.- Immelman with left aileron roll. Pilot F wearing anti-gravity suit; airplane weight, 11,850 pounds; center of gravity at 26.6 percent M.A.C.

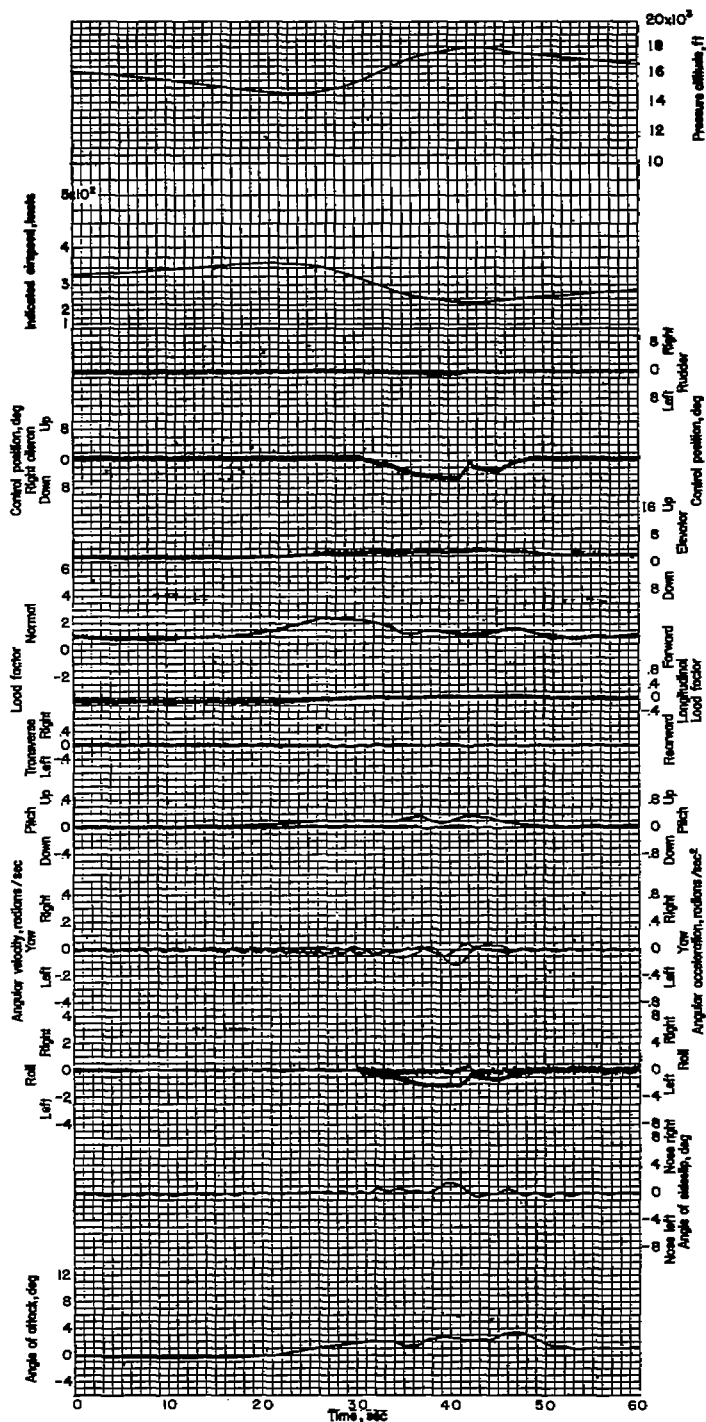


Figure 258.- Immelman with left aileron roll. Pilot F wearing anti-gravity suit and with radar observer; airplane weight, 12,420 pounds; center of gravity at 26.4 percent M.A.C.

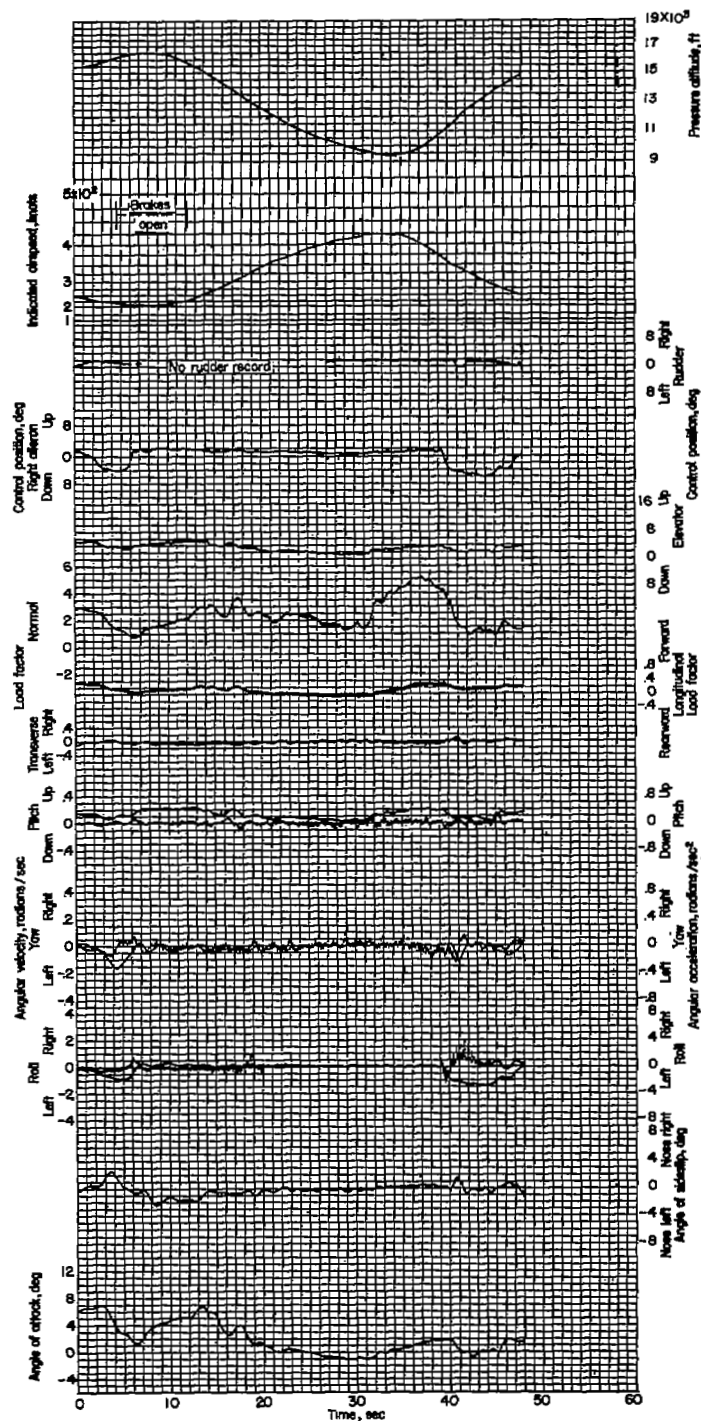


Figure 259.- Split-S followed by left aileron roll. Pilot F wearing anti-gravity suit; airplane weight, 11,770 pounds; center of gravity at 26.4 percent M.A.C.

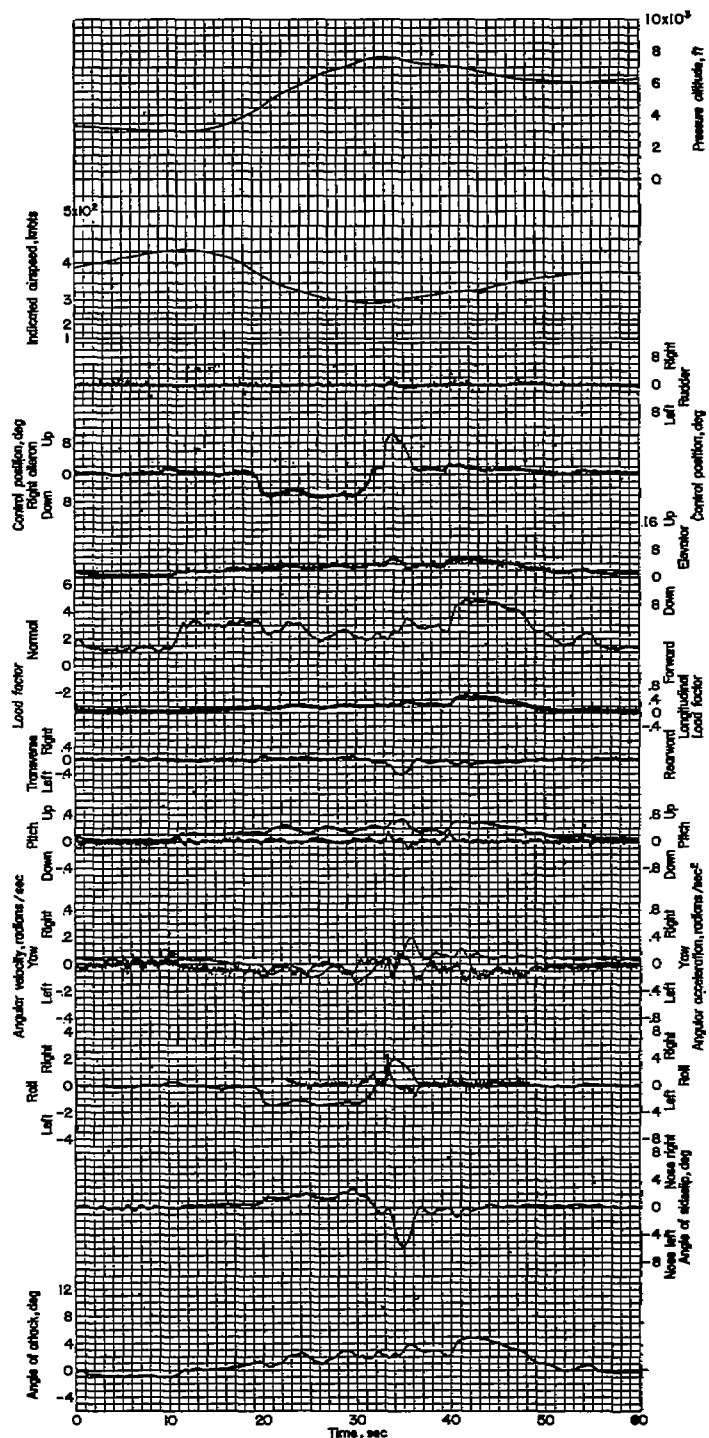


Figure 260.- Two consecutive left aileron rolls followed by a vertical recovery. Pilot G; airplane weight, 12,340 pounds; center of gravity at 27.5 percent M.A.C.

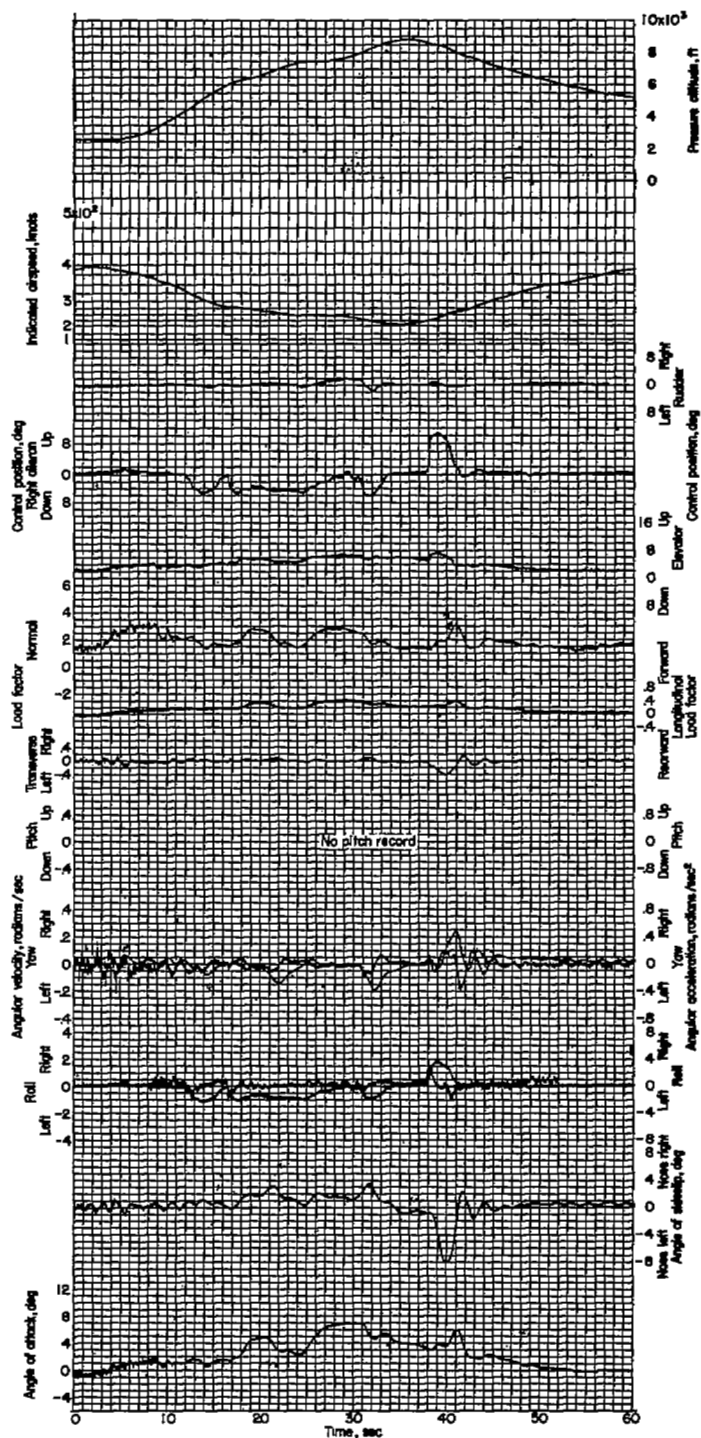


Figure 261.- Left aileron roll followed by vertical recovery. Pilot G with radar observer; airplane weight, 12,460 pounds; center of gravity at 26.5 percent M.A.C.



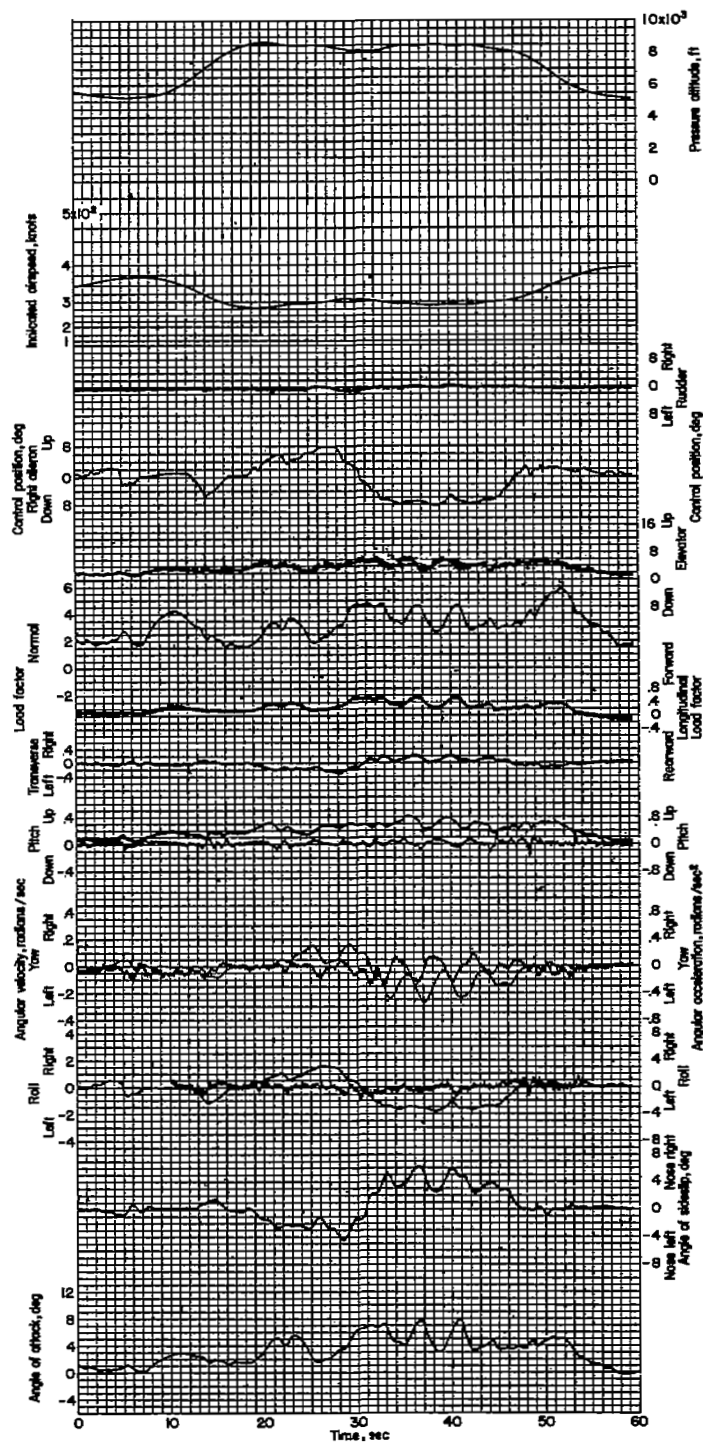


Figure 262.- Vertical recovery into a right aileron roll and two consecutive left aileron rolls followed by a split-S. Pilot G; airplane weight, 12,525 pounds; center of gravity at 27.8 percent M.A.C.

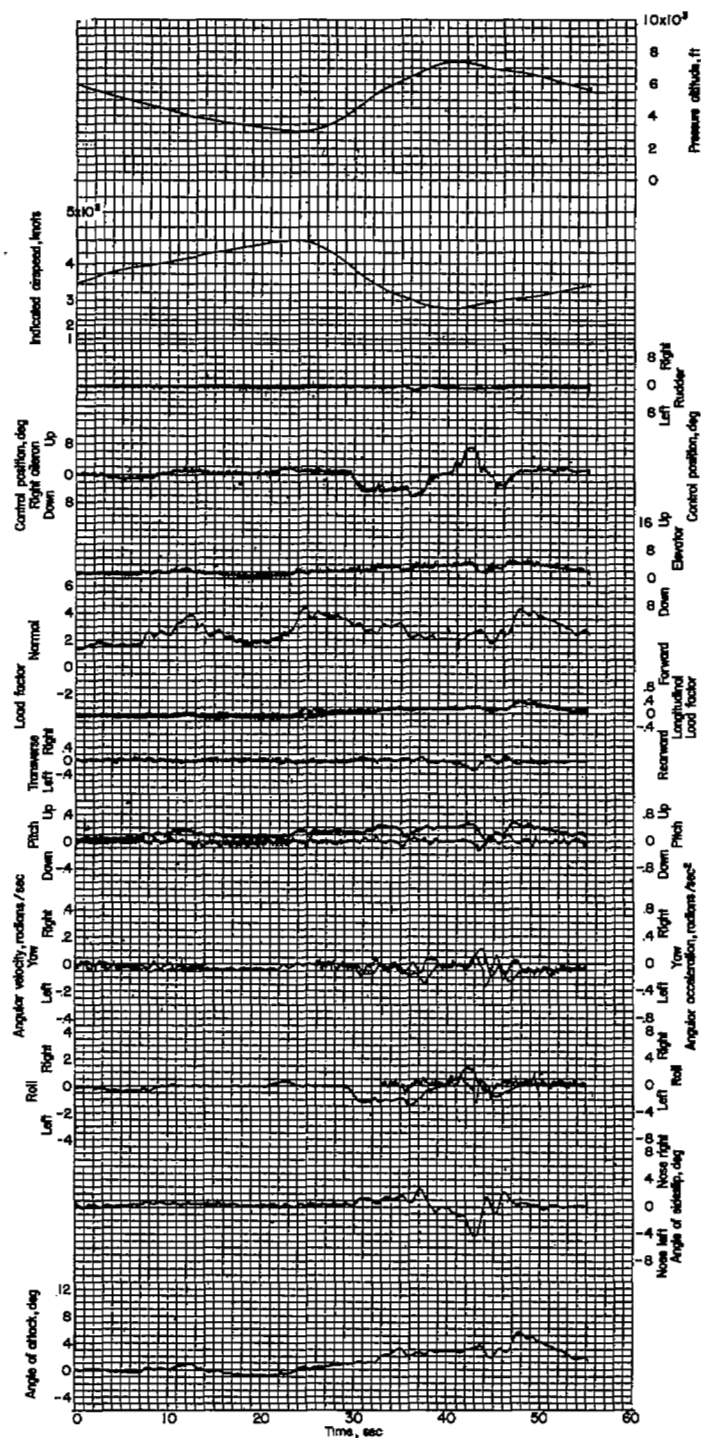


Figure 263.- Vertical recovery with left aileron roll. Pilot G; airplane weight, 12,580 pounds; center of gravity at 27.7 percent M.A.C.

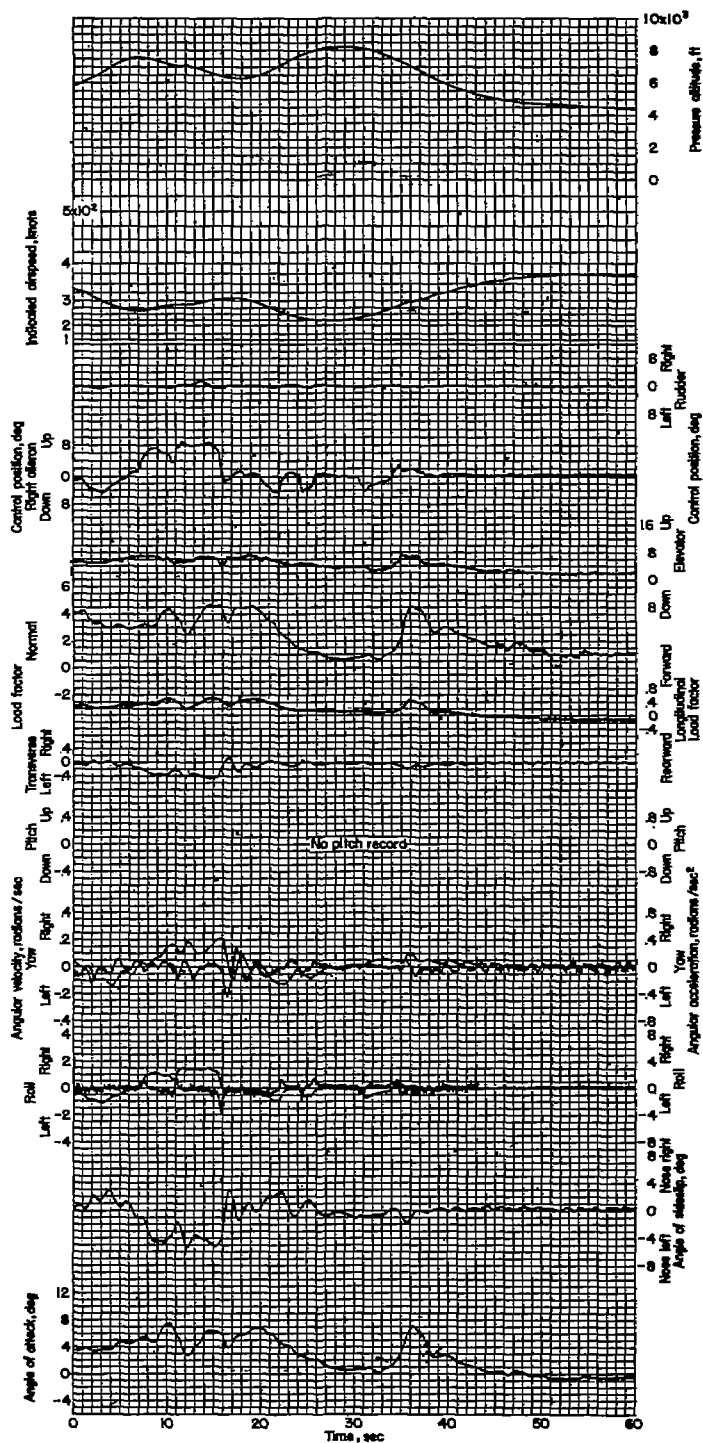


Figure 264.- Vertical recovery followed by right aileron roll into a wing-over. Pilot G with radar observer; airplane weight, 12,150 pounds; center of gravity at 25.9 percent M.A.C.

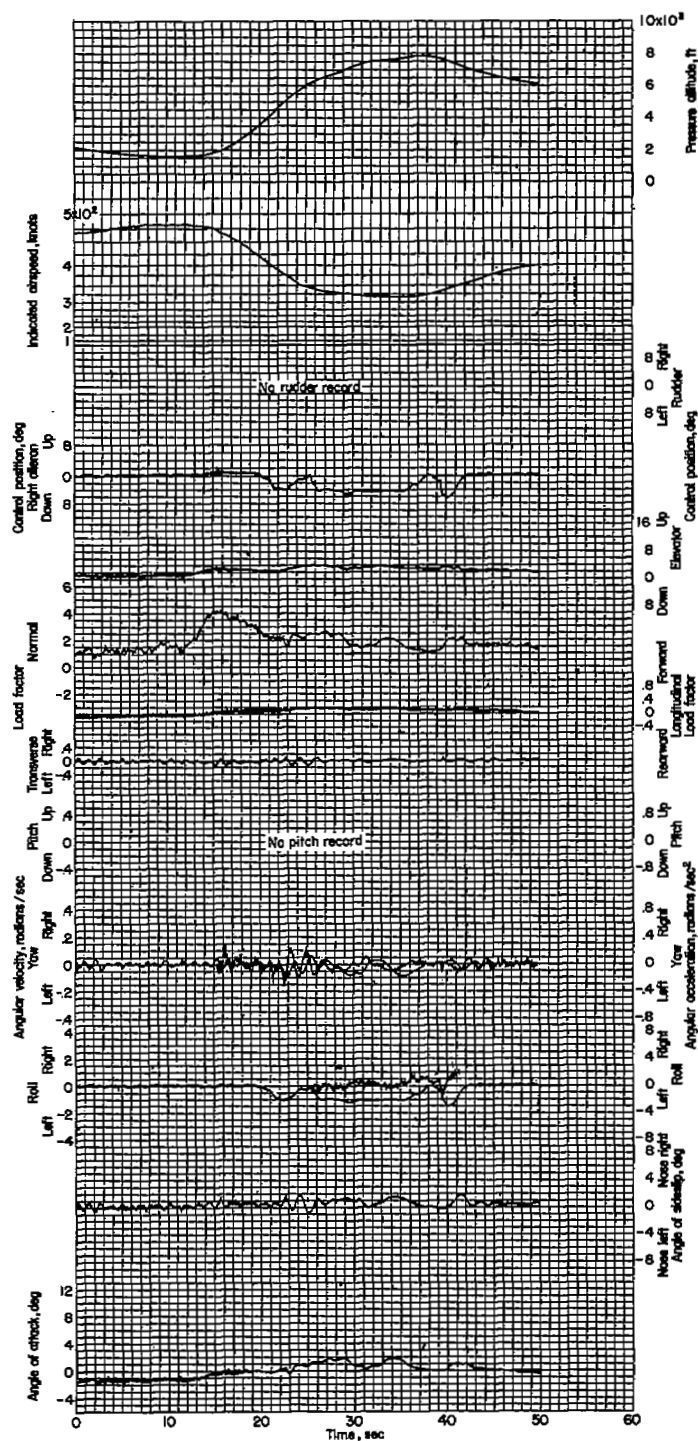


Figure 265.- Vertical recovery with two consecutive left aileron rolls. Pilot G with radar observer; airplane weight, 12,630 pounds; center of gravity at 26.8 percent M.A.C.

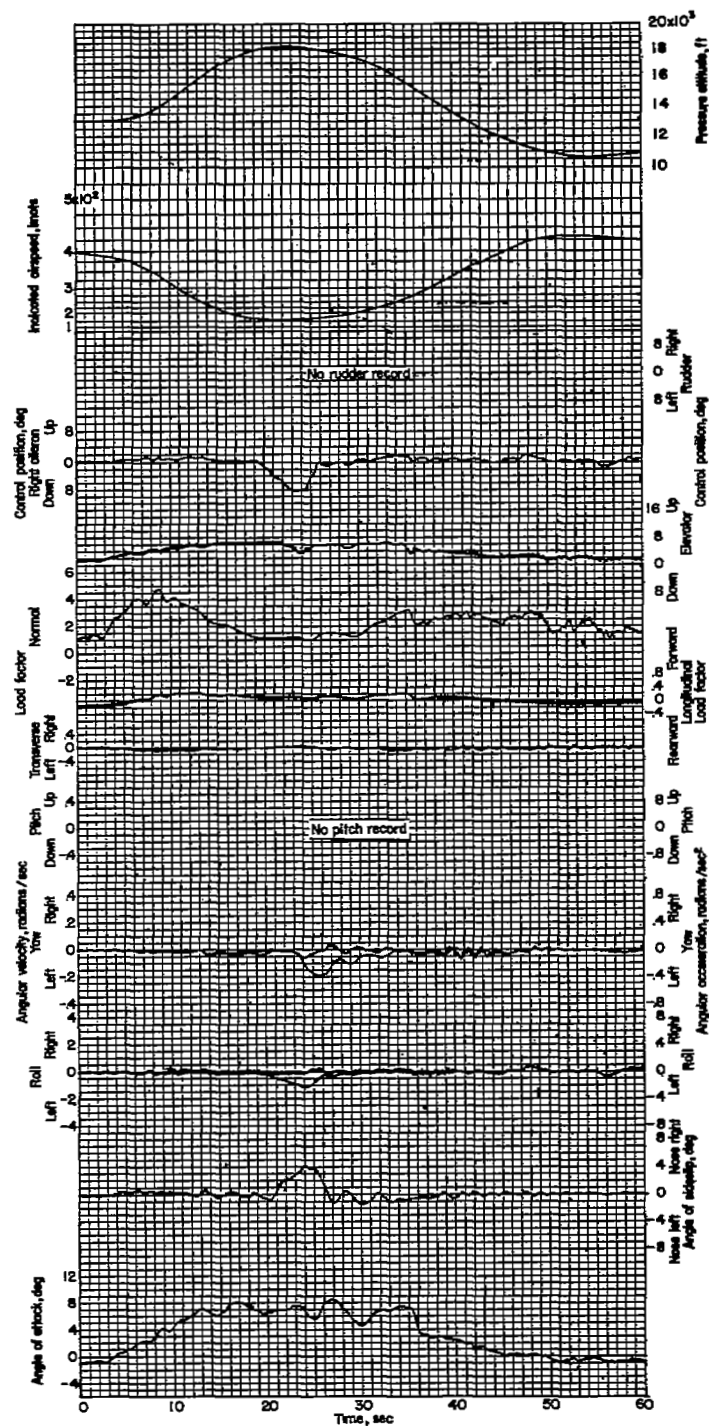


Figure 266.- Loop with left aileron roll on top. Pilot G with radar observer; airplane weight, 12,145 pounds; center of gravity at 25.8 percent M.A.C.

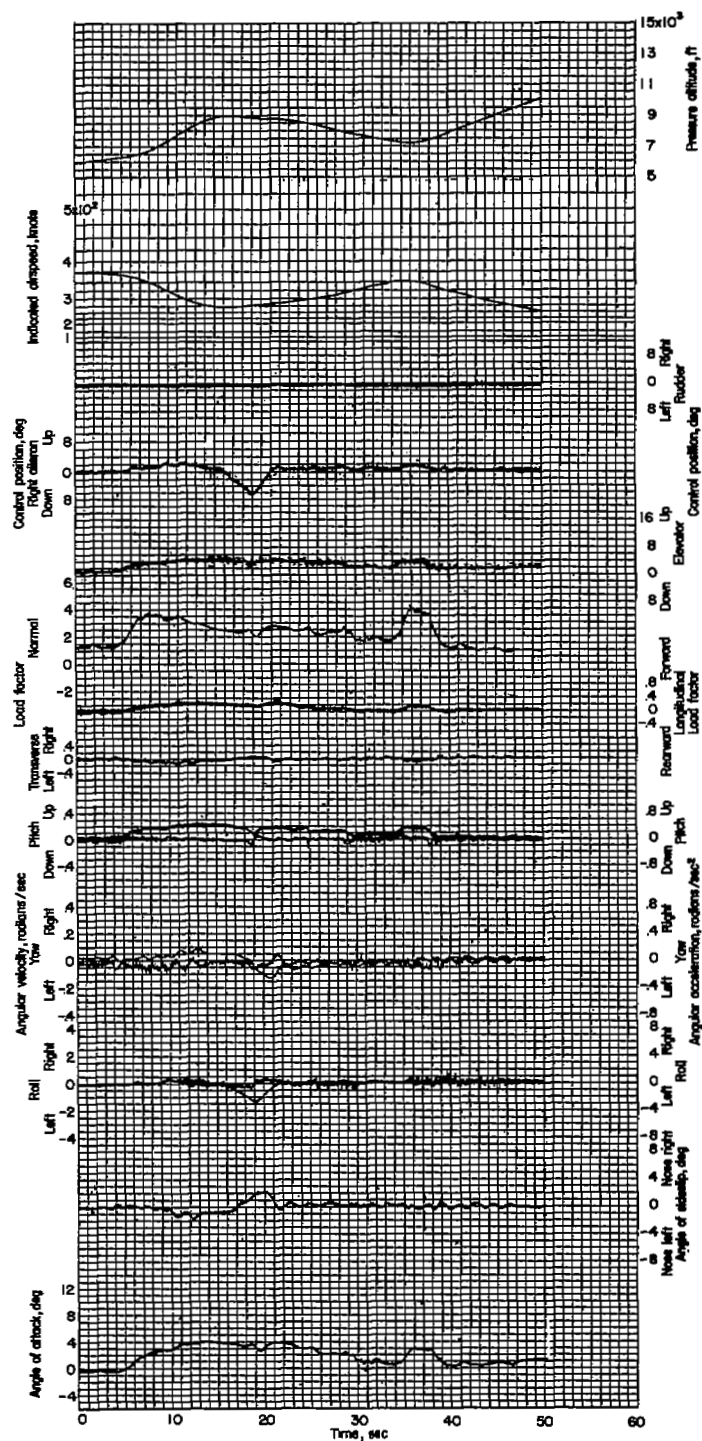


Figure 267.- Immelman followed by a pull-up. Pilot G; airplane weight, 12,280 pounds; center of gravity at 27.4 percent M.A.C.

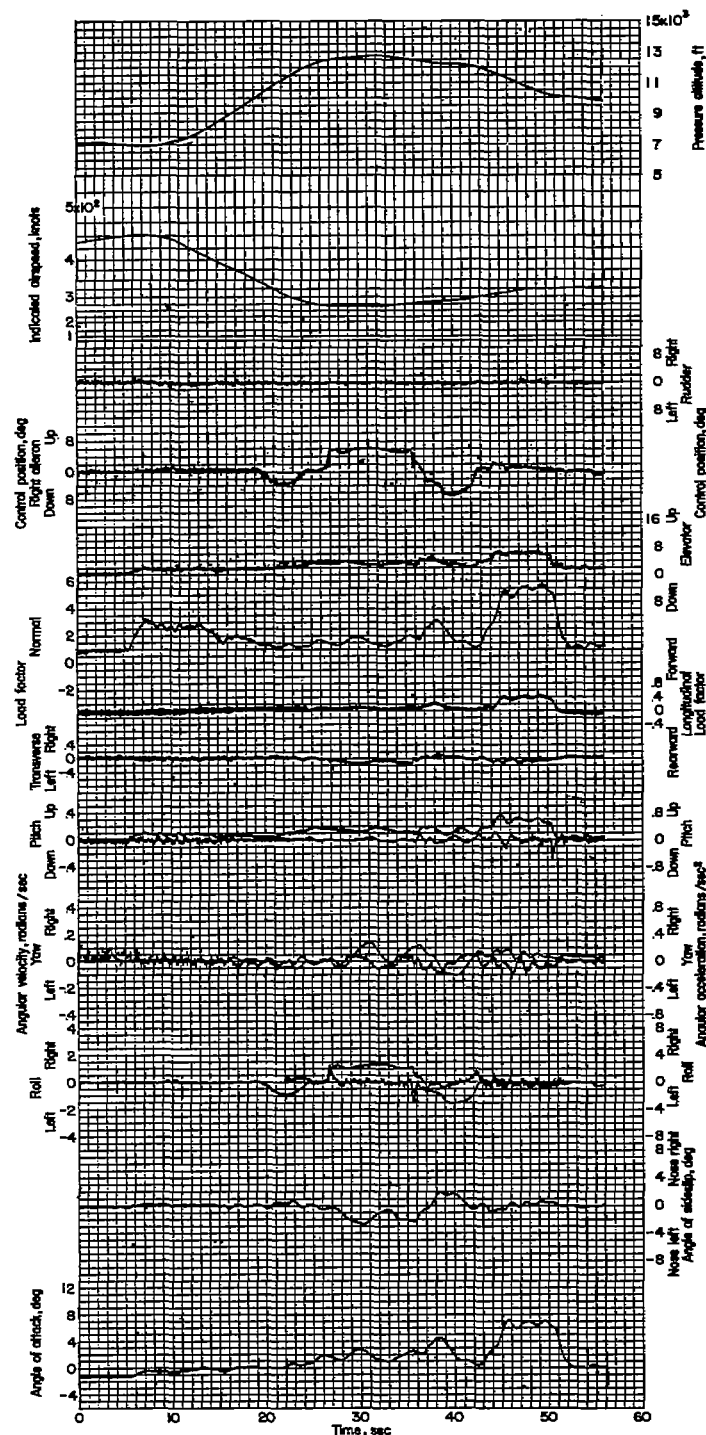


Figure 268.- Immelman into two consecutive right aileron rolls followed by left aileron roll. Pilot G; airplane weight, 12,000 pounds; center of gravity at 26.9 percent M.A.C.

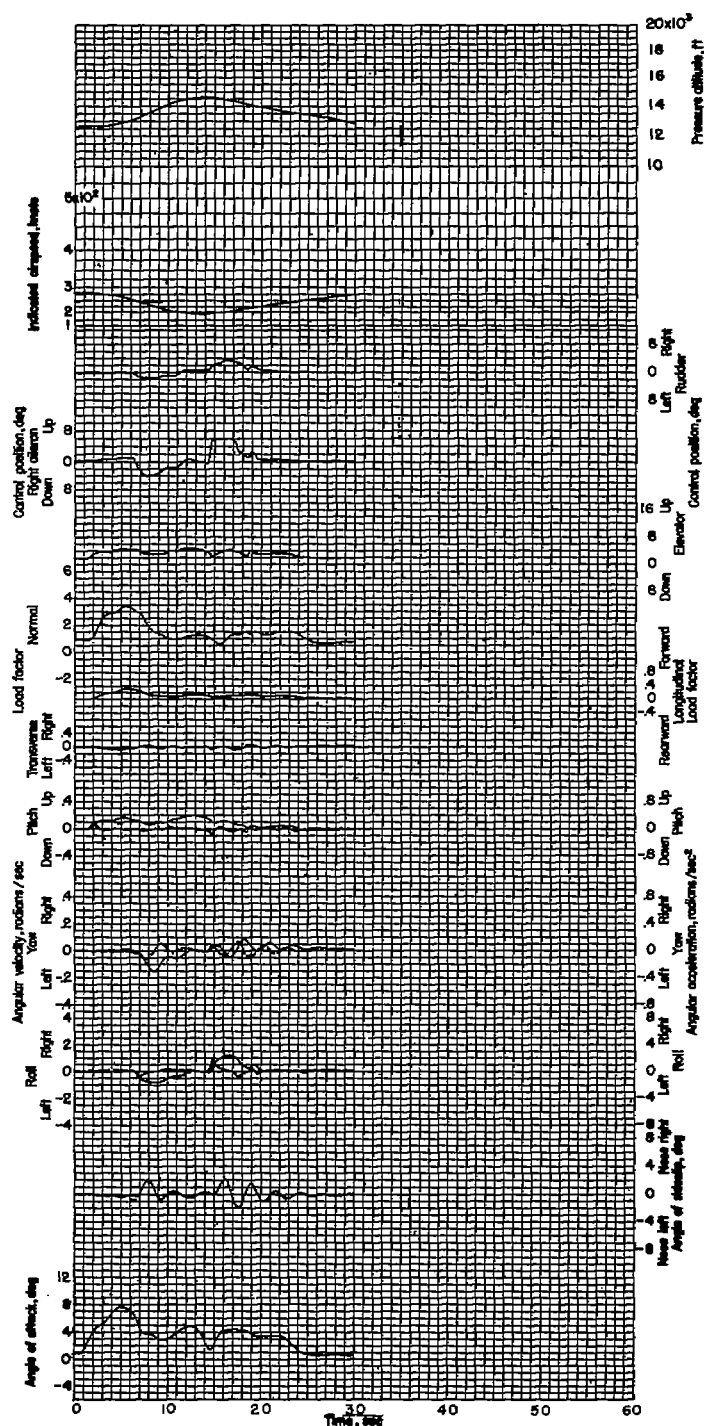


Figure 269.- Vertical recovery. Pilot A; airplane weight, 12,275 pounds; center of gravity at 27.4 percent M.A.C.



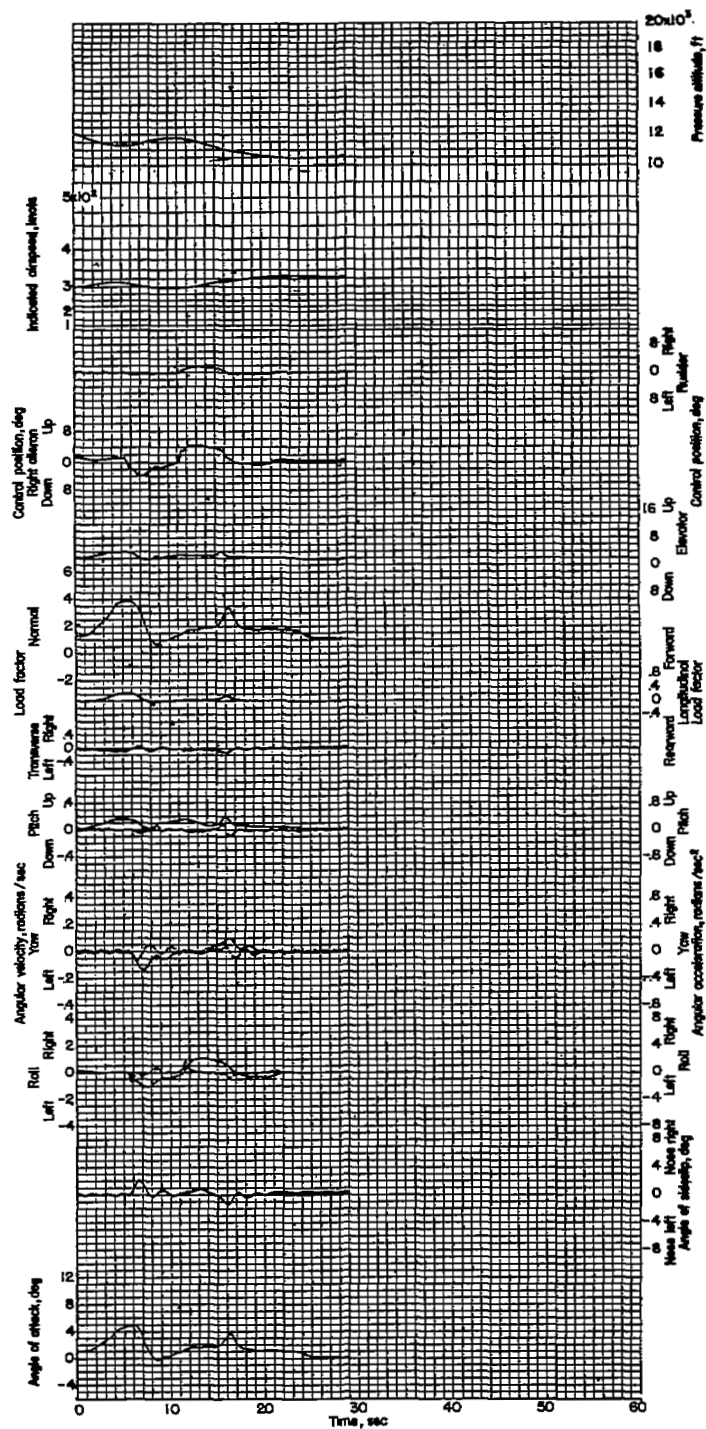


Figure 270.- Vertical recovery. Pilot A; airplane weight, 12,450 pounds; center of gravity at 27.7 percent M.A.C.

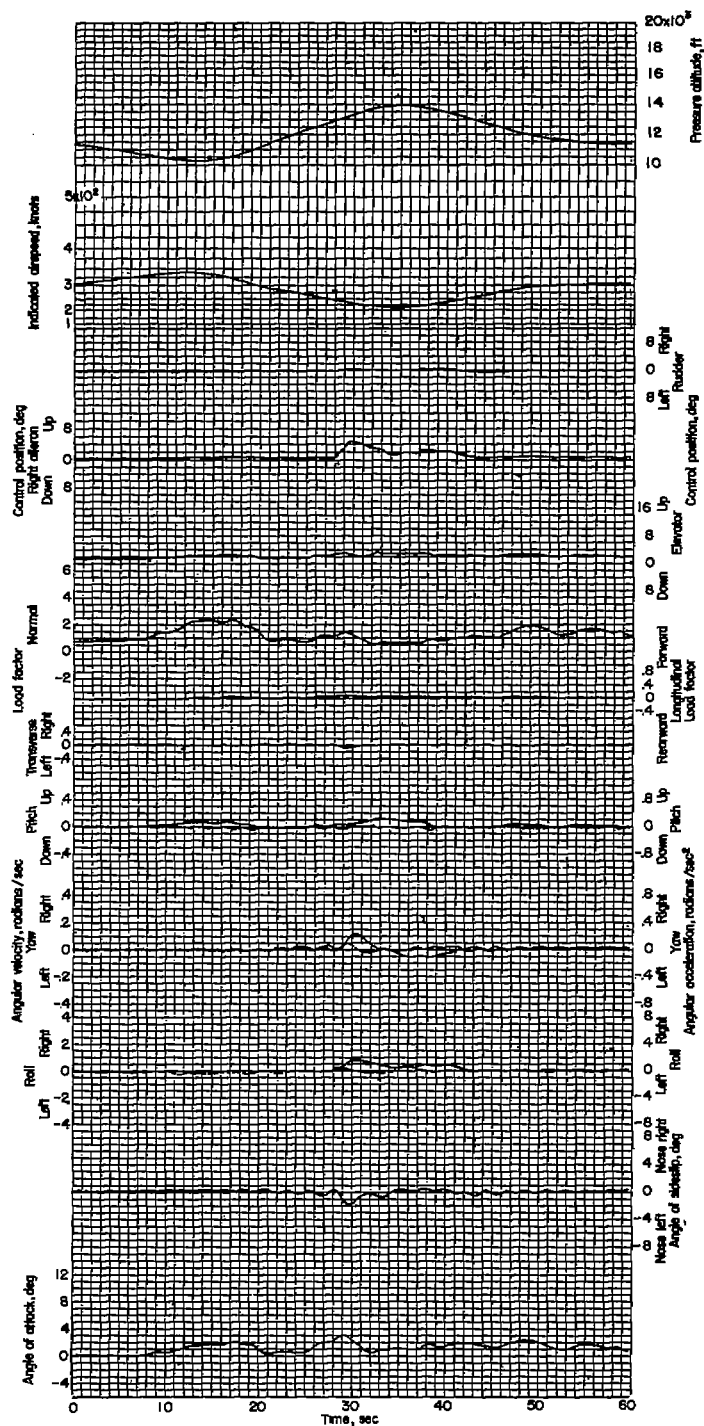


Figure 271.- Vertical recovery. Pilot A; airplane weight, 12,370 pounds; center of gravity at 27.6 percent M.A.C.

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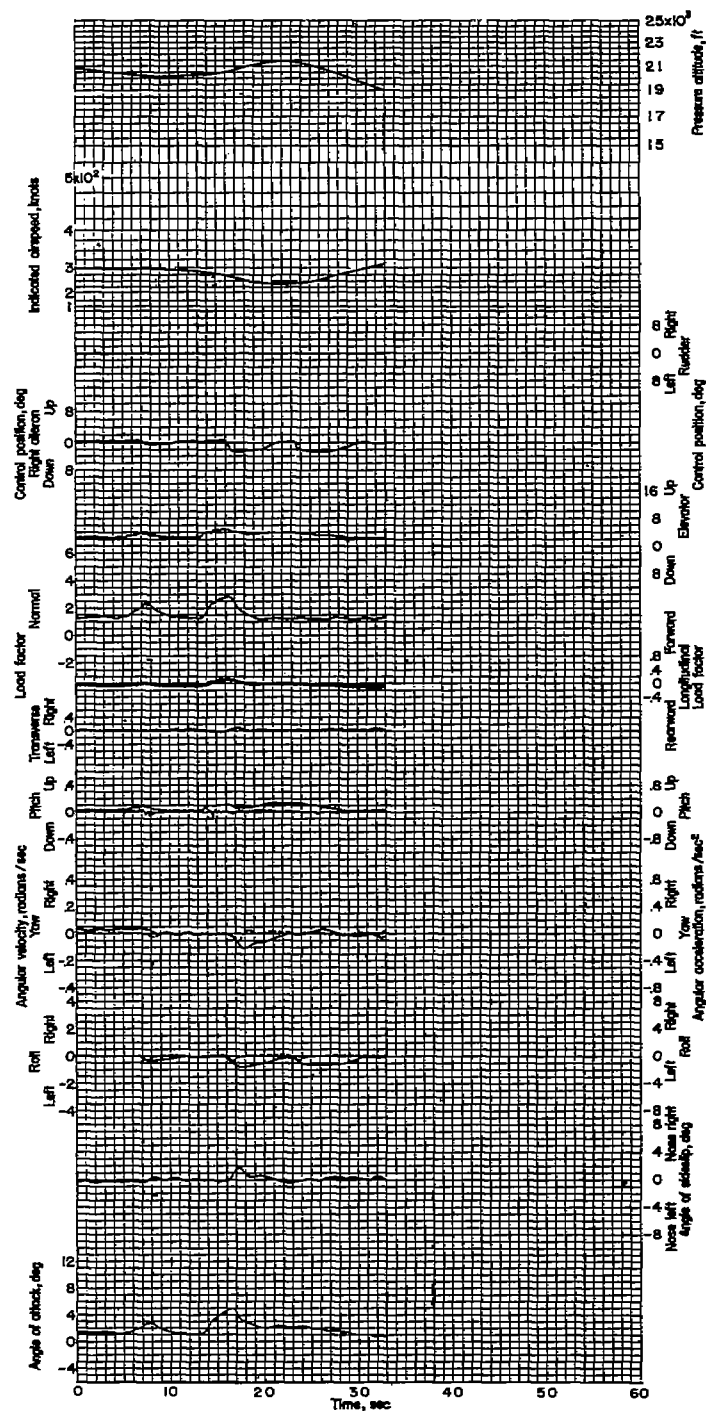


Figure 272.- Vertical recovery. Pilot B with radar observer; airplane weight, 12,105 pounds; center of gravity at 25.8 percent M.A.C.

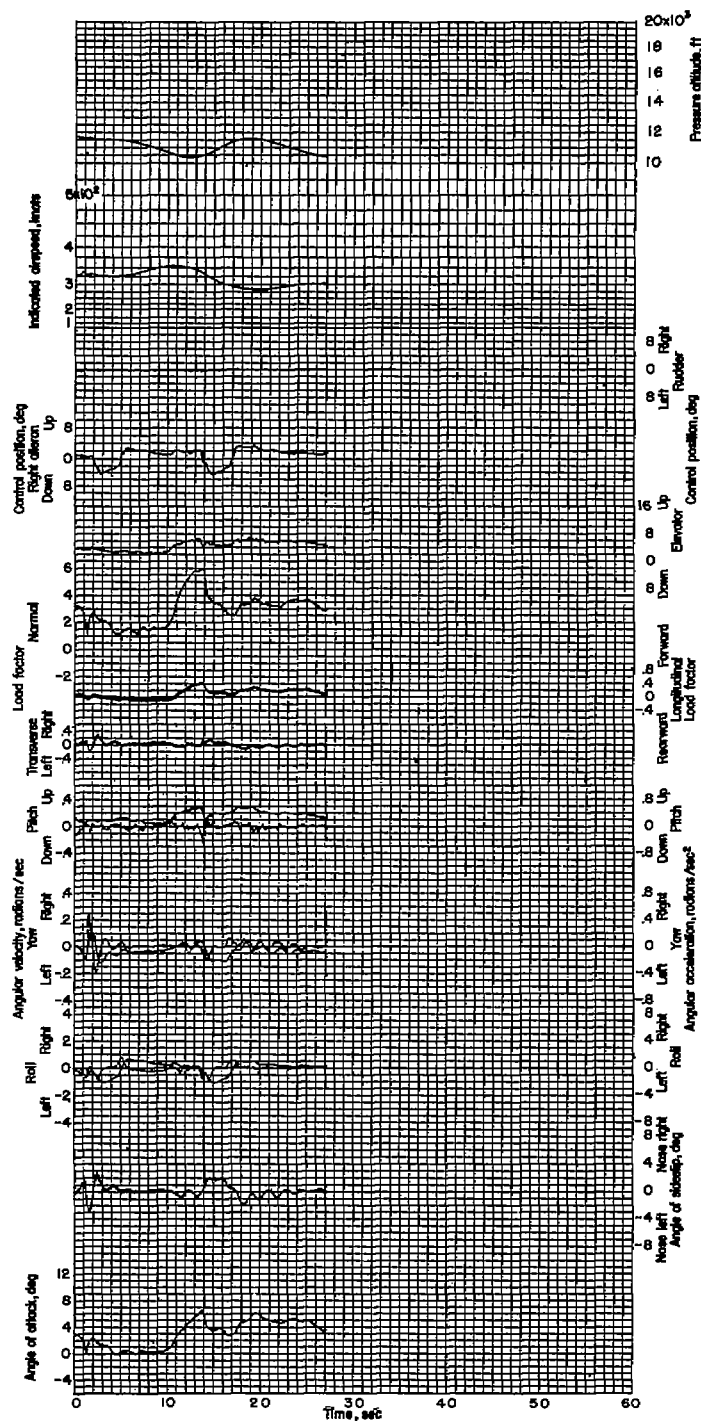


Figure 273.- Vertical recovery. Pilot B with radar observer; airplane weight, 12,035 pounds; center of gravity at 25.6 percent M.A.C.

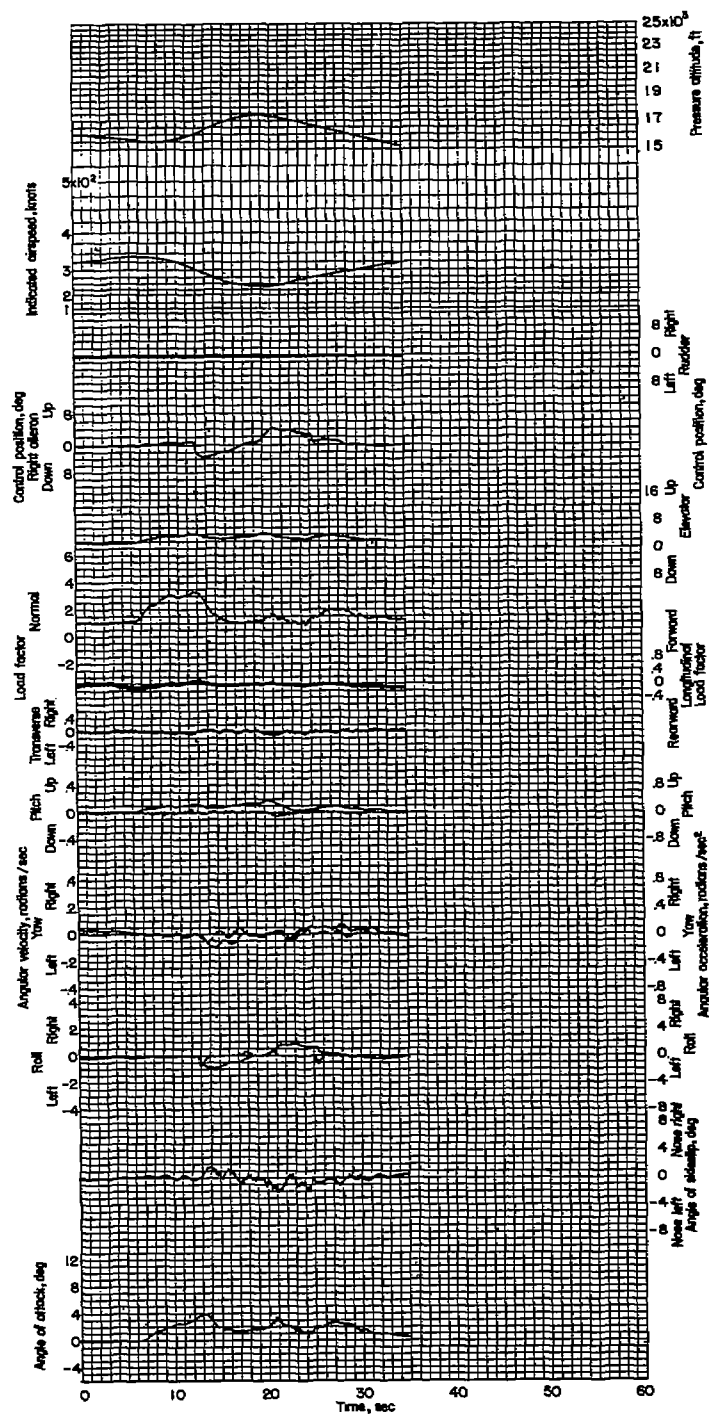


Figure 274.- Vertical recovery. Pilot B with radar observer; airplane weight, 12,080 pounds; center of gravity at 25.7 percent M.A.C.

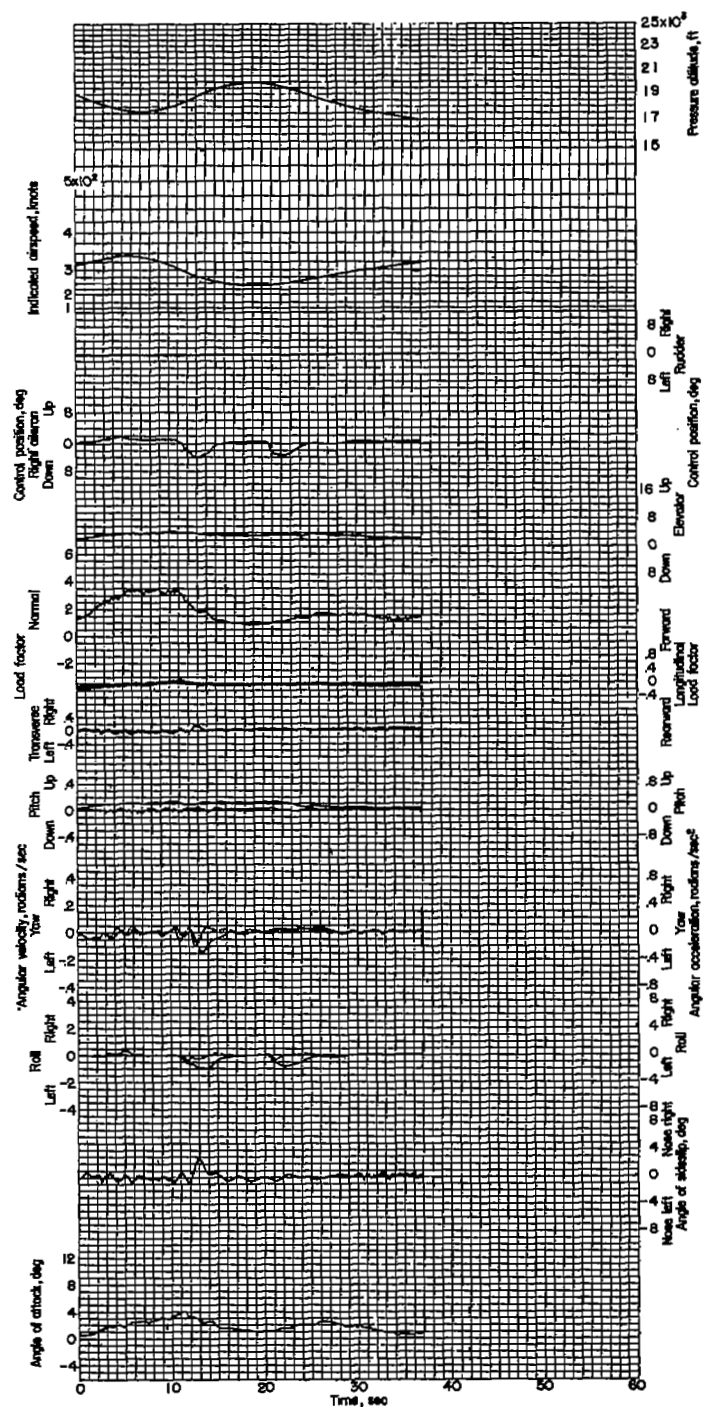


Figure 275.- Vertical recovery. Pilot B with radar observer; airplane weight, 12,095 pounds; center of gravity at 25.7 percent M.A.C.

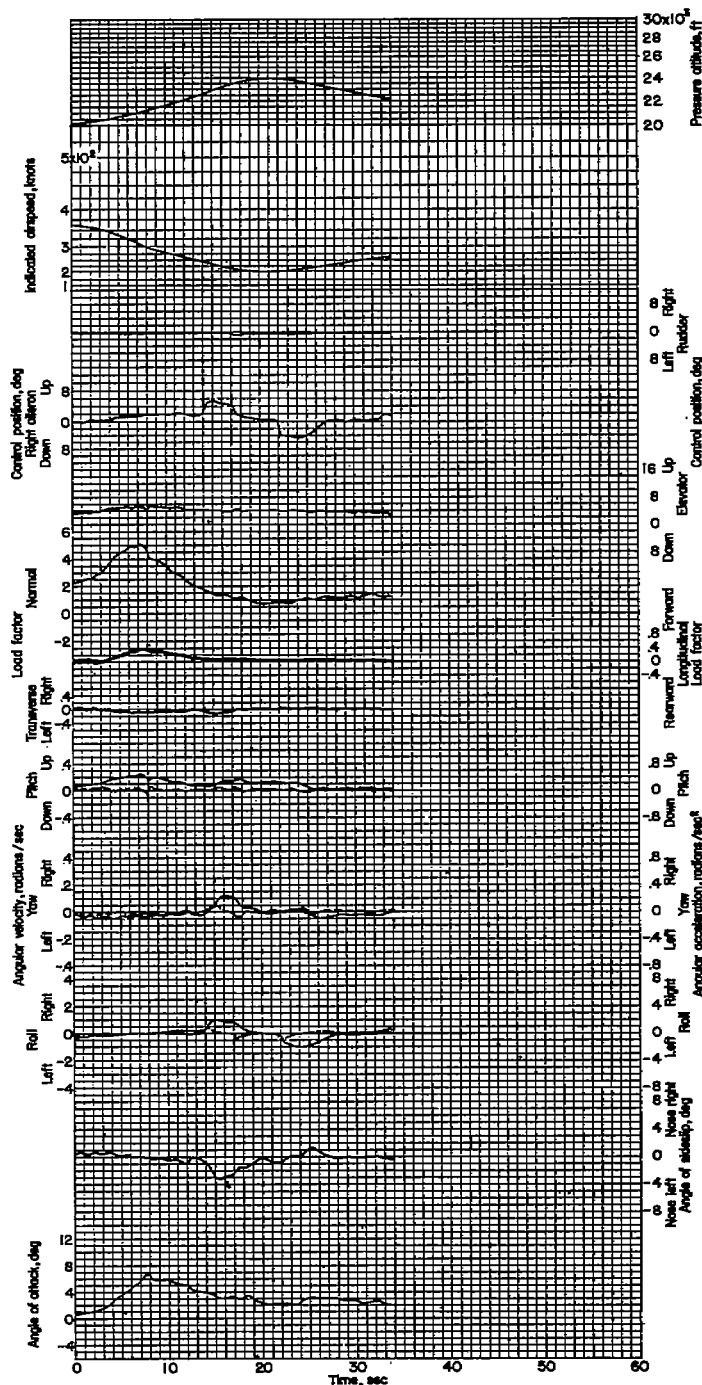


Figure 276.- Vertical recovery. Pilot B with radar observer; airplane weight, 12,125 pounds; center of gravity at 25.8 percent M.A.C.

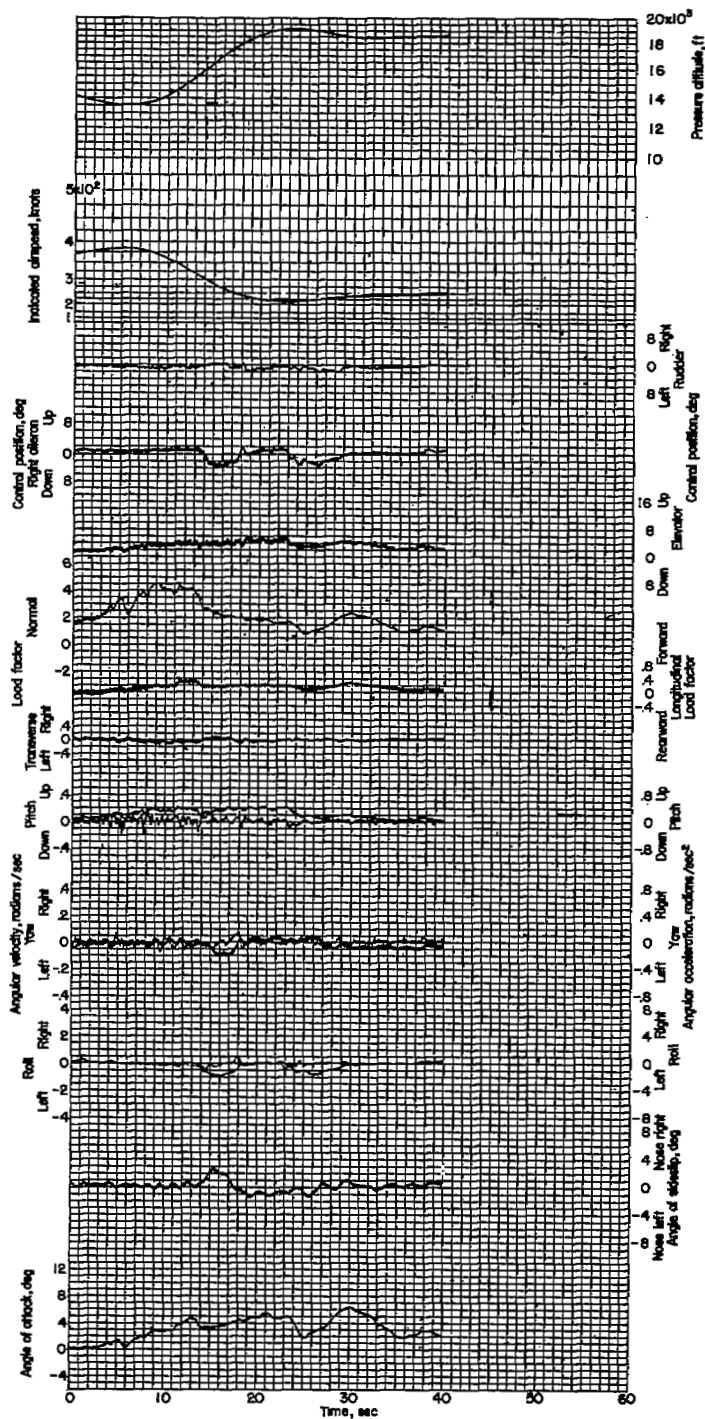


Figure 277.- Vertical recovery. Pilot C with radar observer; airplane weight, 12,580 pounds; center of gravity at 26.7 percent M.A.C.

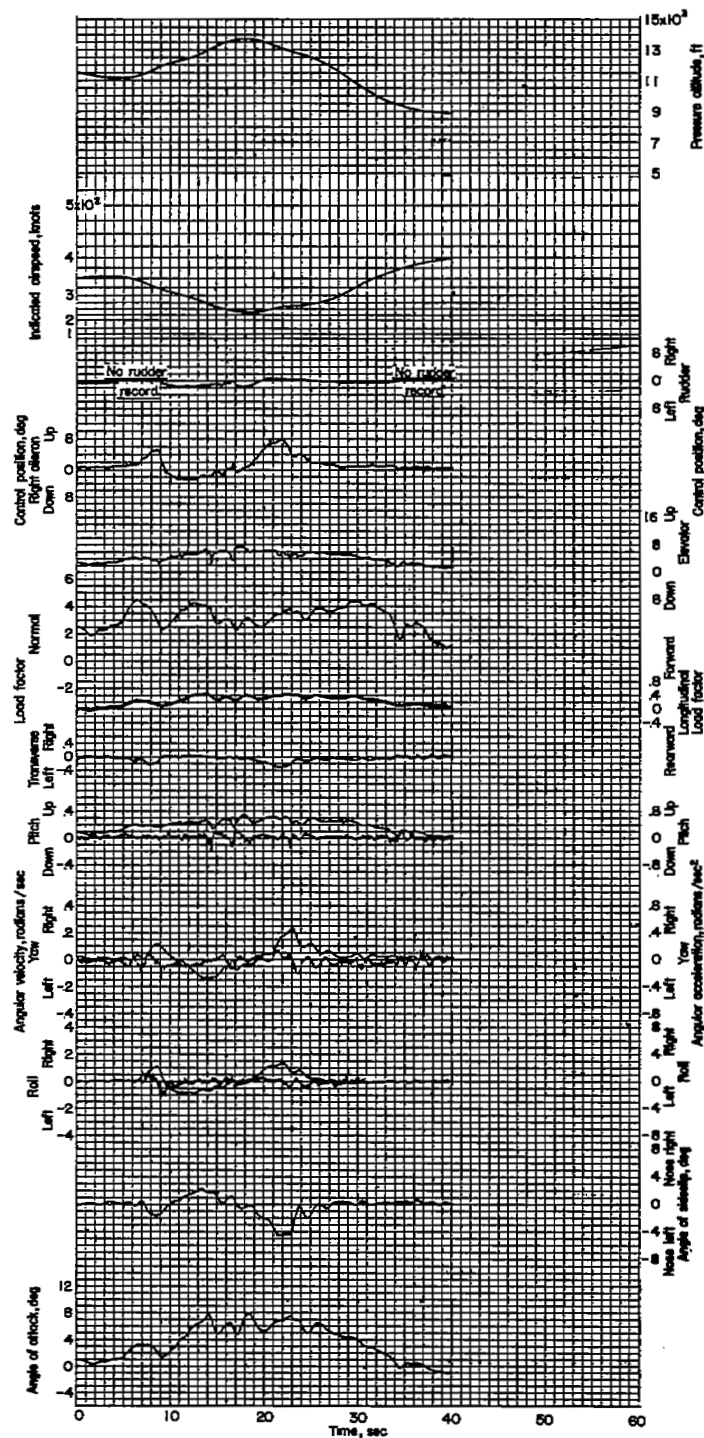


Figure 278.- Vertical recovery. Pilot F wearing anti-gravity suit; airplane weight, 11,700 pounds; center of gravity at 26.3 percent M.A.C.

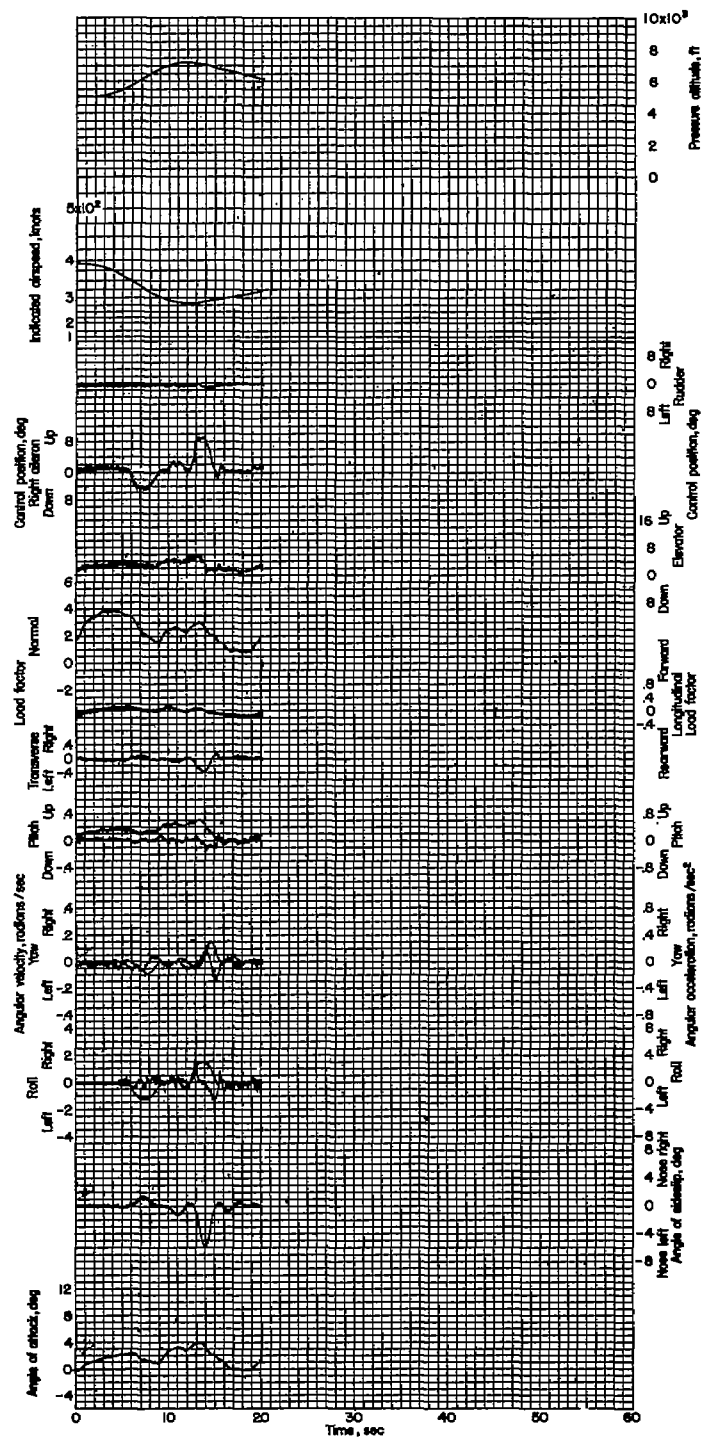


Figure 279.- Vertical recovery. Pilot G; airplane weight, 12,490 pounds; center of gravity at 27.8 percent M.A.C.



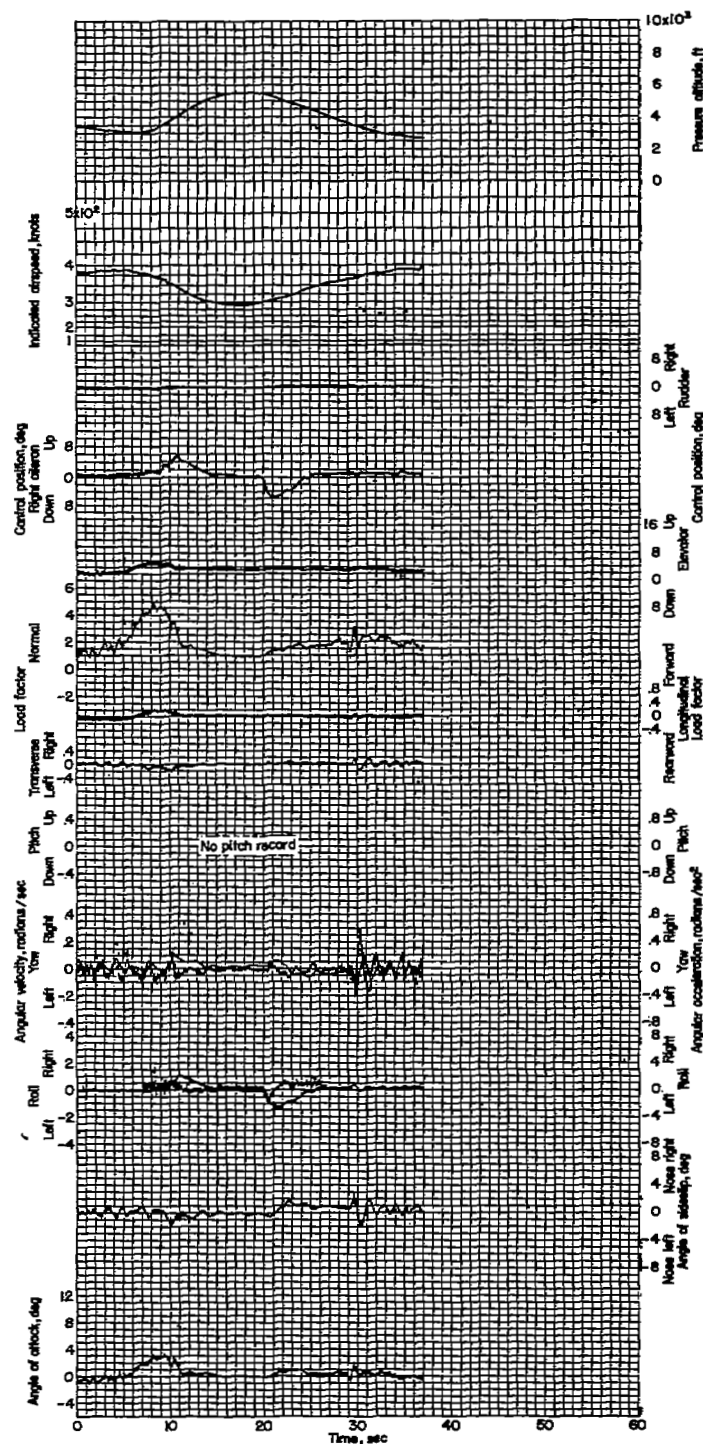


Figure 280.- Vertical recovery. Pilot G with radar observer; airplane weight, 12,520 pounds; center of gravity at 26.6 percent M.A.C.

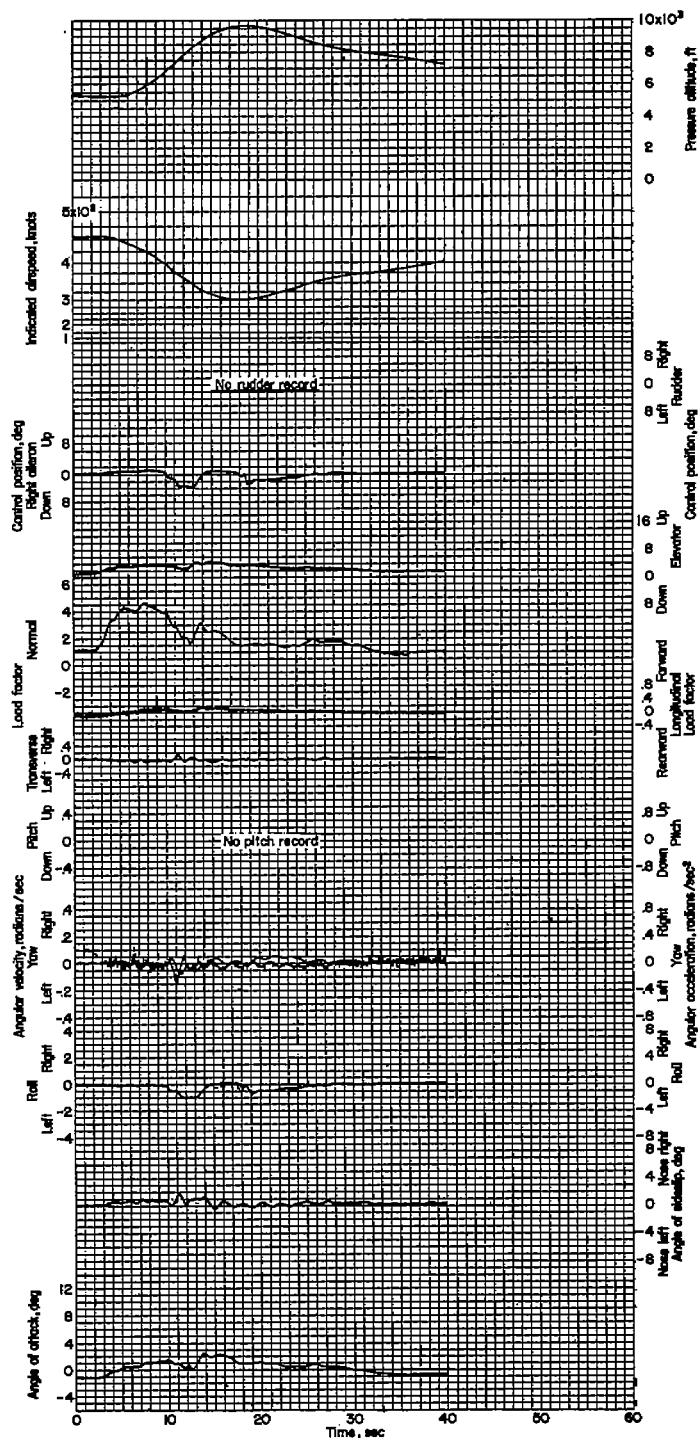


Figure 281.- Vertical recovery. Pilot G with radar observer; airplane weight, 12,735 pounds; center of gravity at 26.9 percent M.A.C.

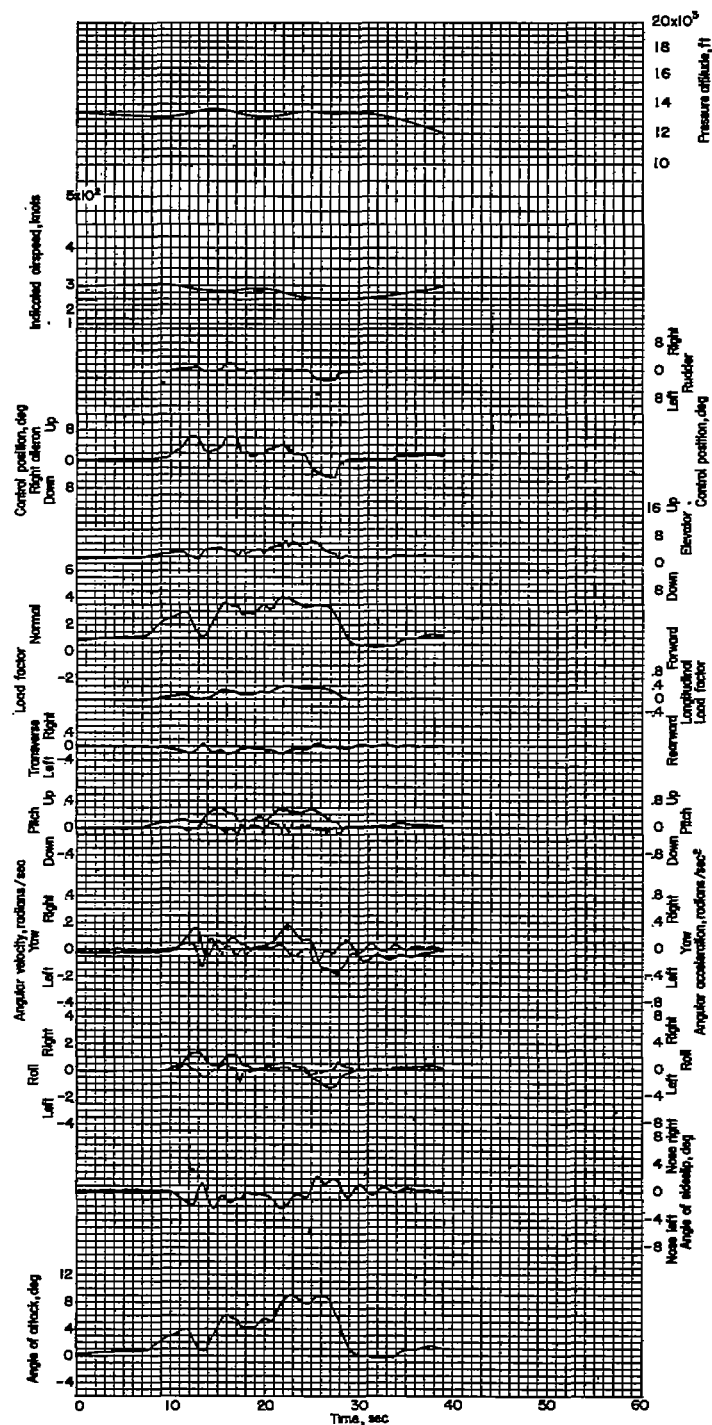


Figure 282.- Vertical recovery followed by right and left turns. Pilot A; airplane weight, 12,490 pounds; center of gravity at 27.8 percent M.A.C.

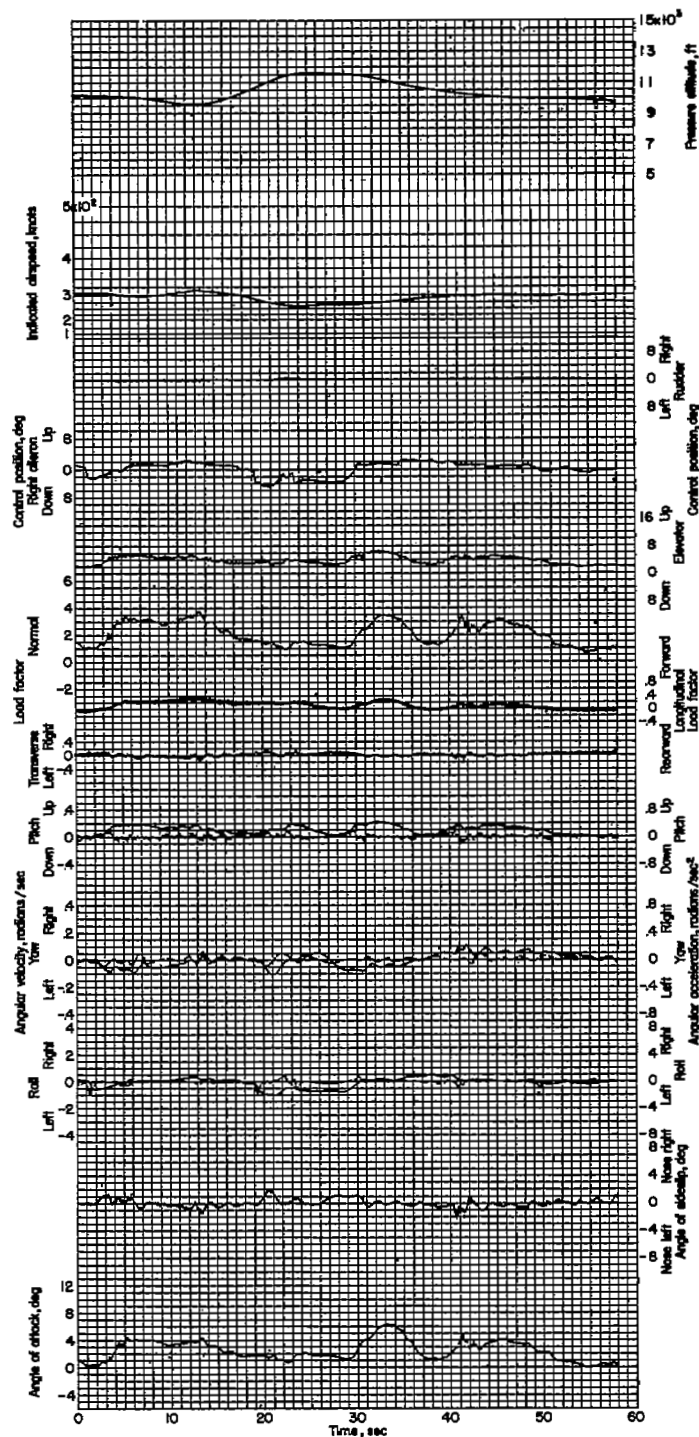


Figure 283.- Vertical recovery followed by turns. Pilot B with radar observer; airplane weight, 12,015 pounds; center of gravity at 25.6 percent M.A.C.

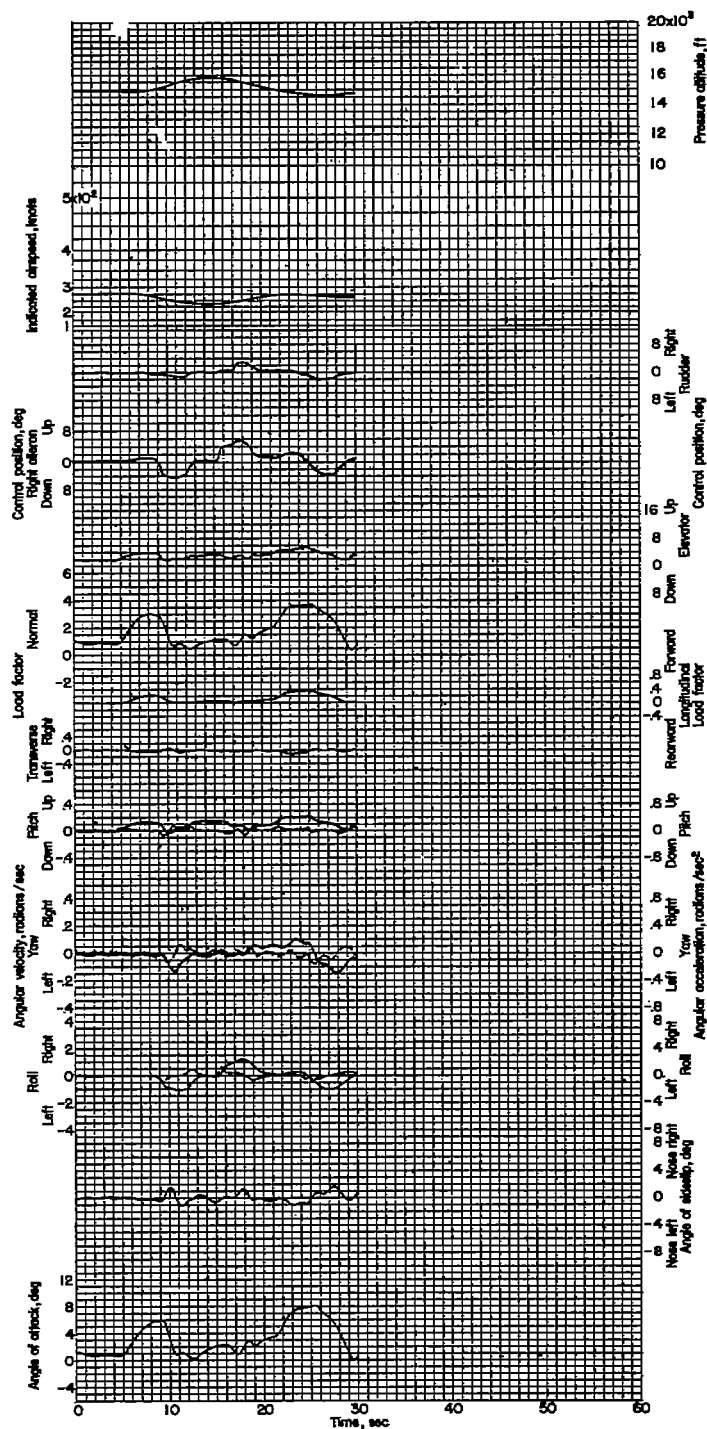
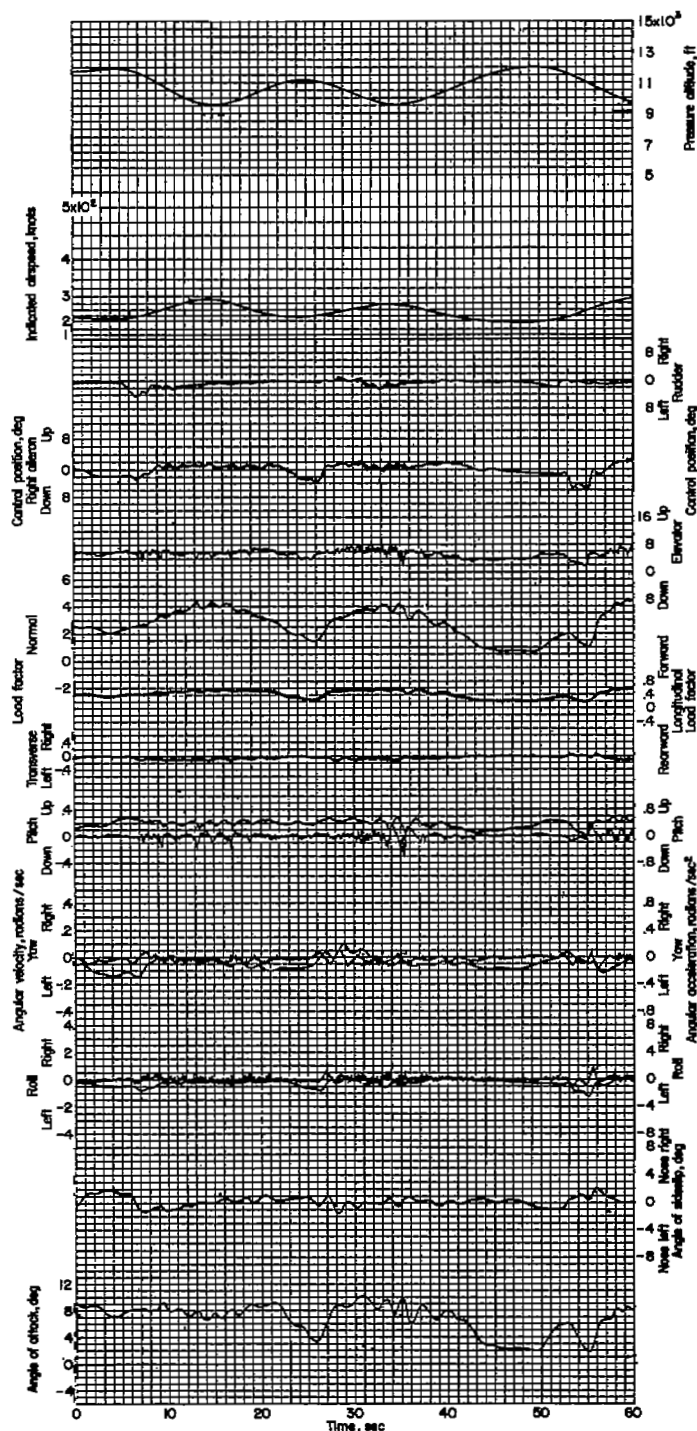


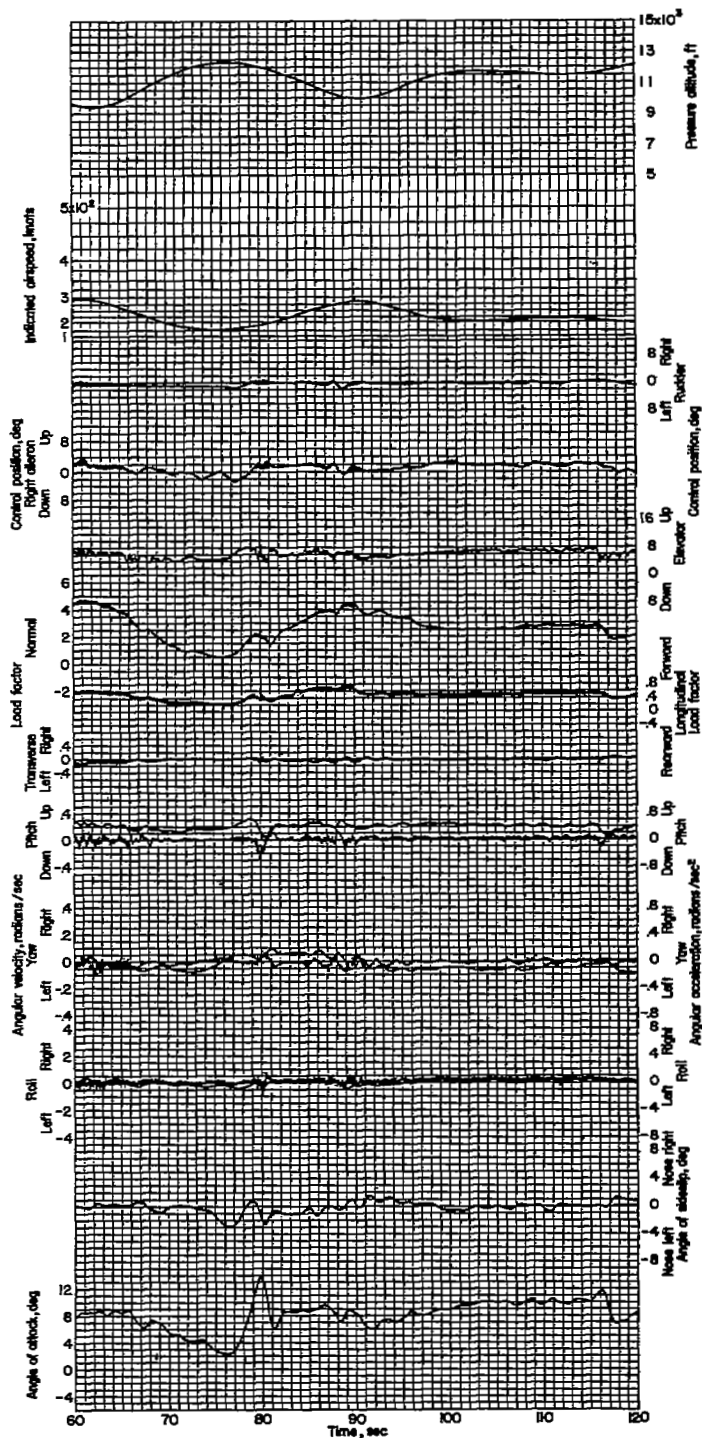
Figure 284.- Vertical recovery followed by right and left turns. Pilot A; airplane weight, 12,200 pounds; center of gravity at 27.3 percent M.A.C.



(a)



Figure 285.- Series of maneuvers. Pilot F wearing anti-gravity suit; airplane weight, 12,300 pounds; center of gravity at 27.5 percent M.A.C.



(b)



Figure 285.- Concluded.

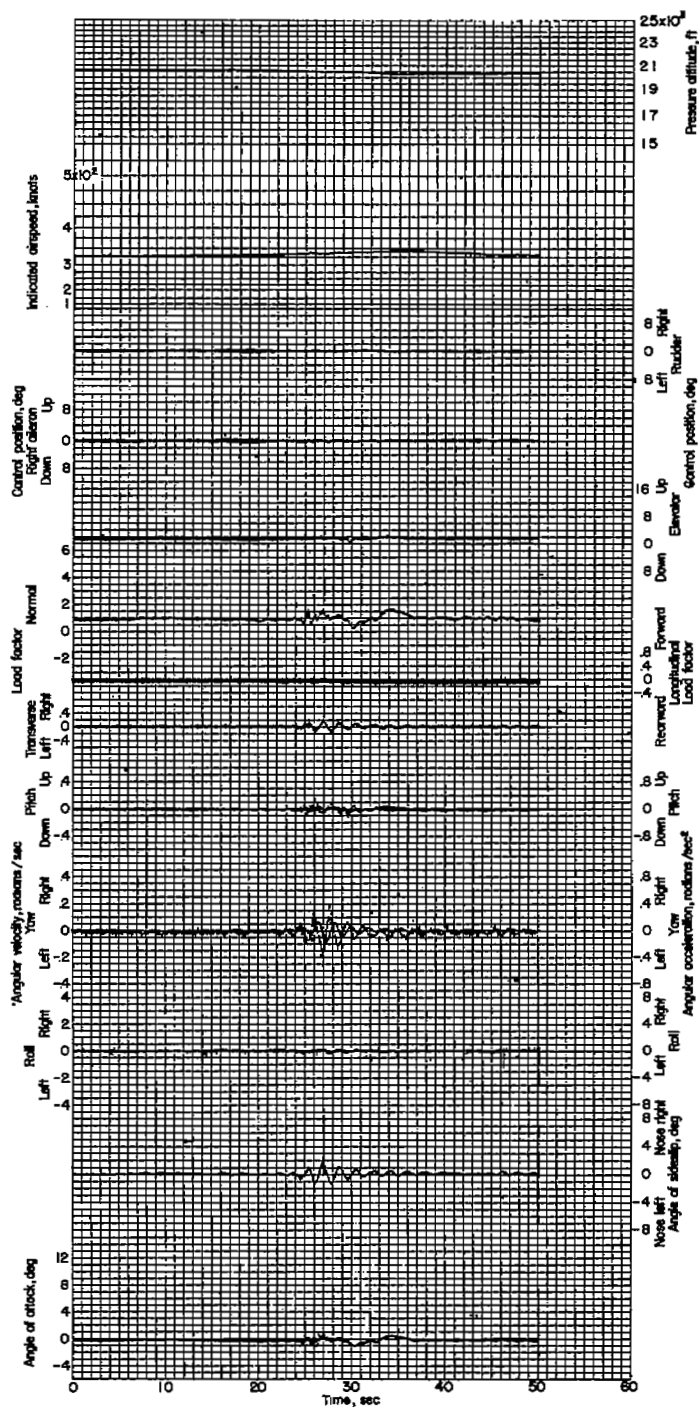


Fig 286.- Directional oscillations. Pilot A; airplane weight, 12,190 pounds; center of gravity at 27.3 percent M.A.C.

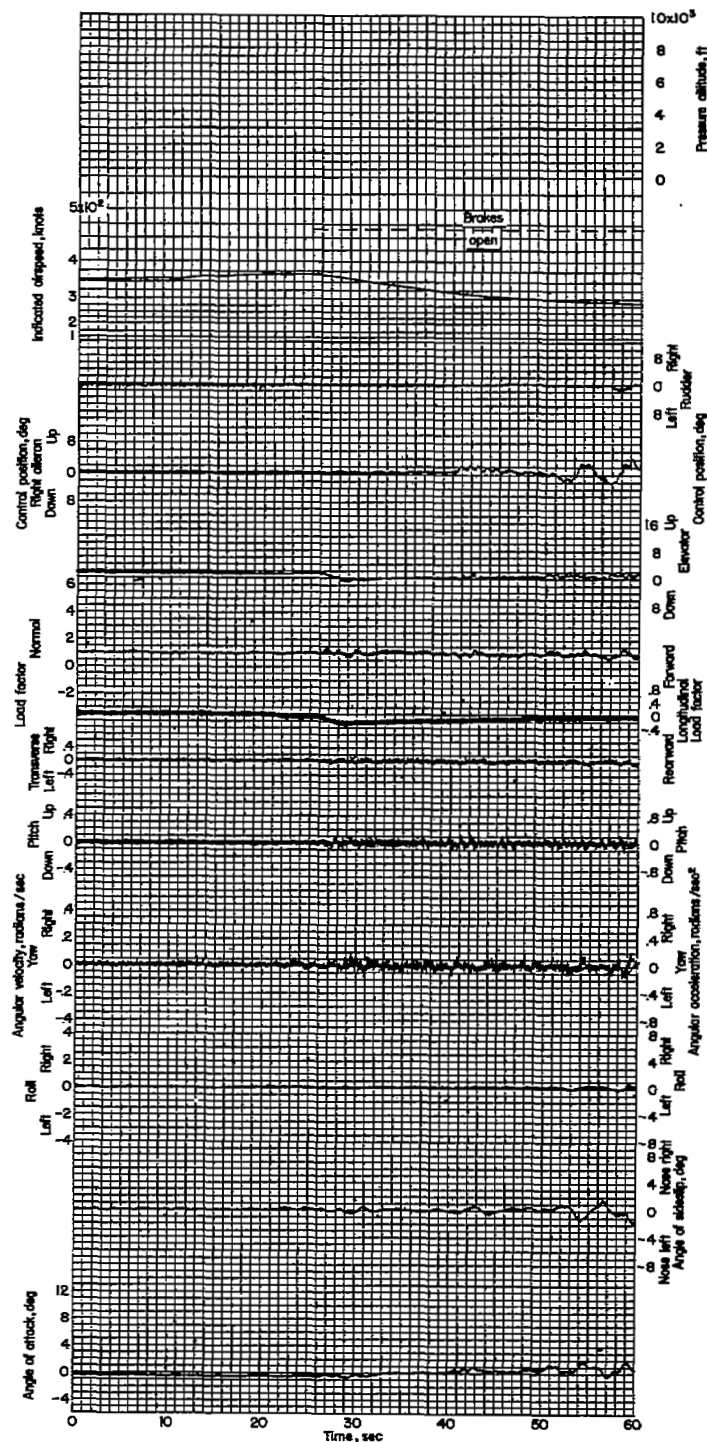


Figure 287.- Interception. Pilot E wearing anti-gravity suit and with radar observer; tip tanks on; airplane weight, 15,030 pounds; center of gravity at 27.8 percent M.A.C.

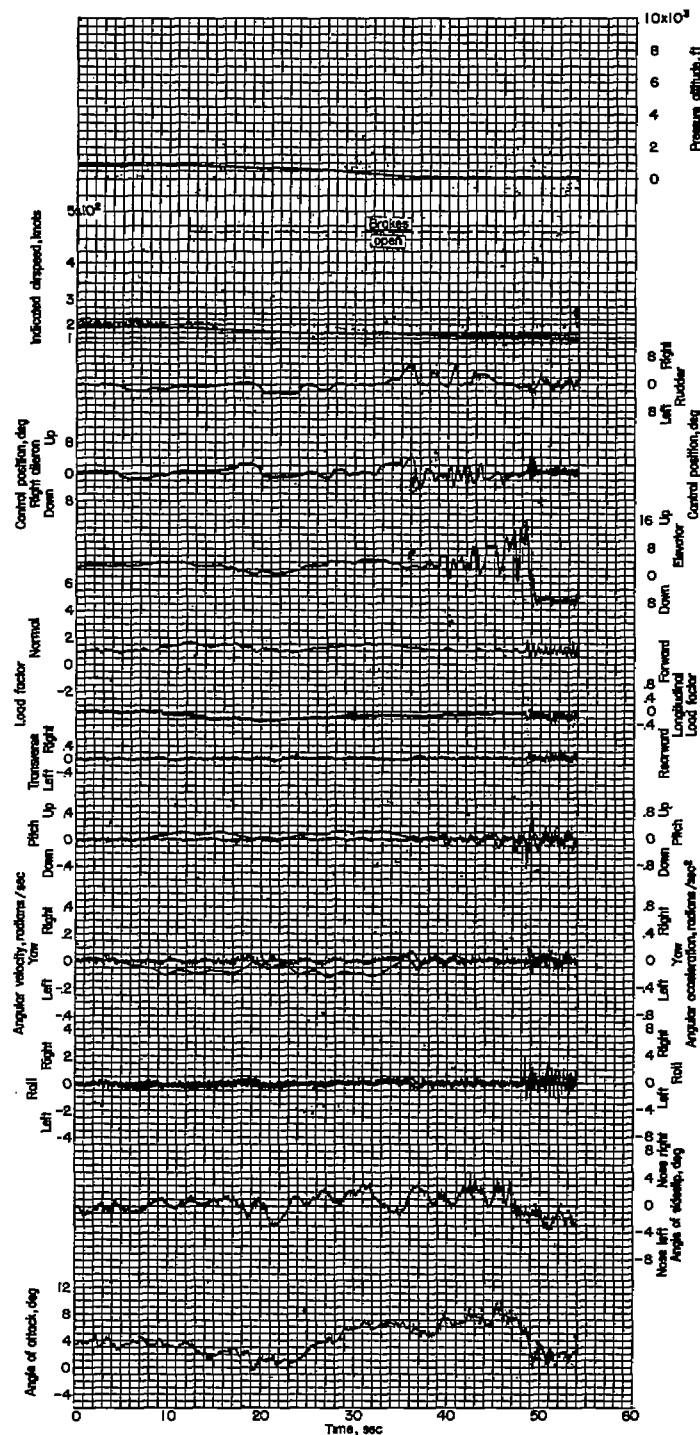
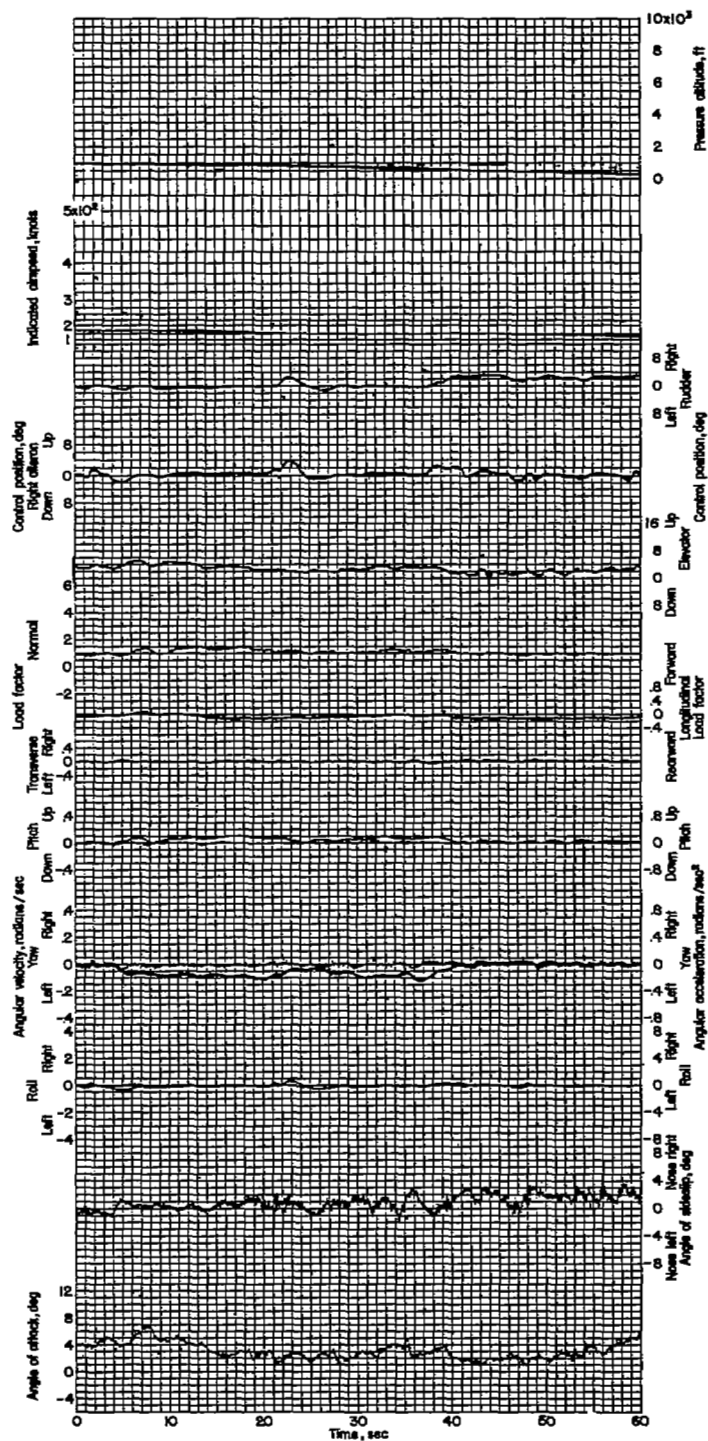


Figure 288.- Landing. Pilot A; airplane weight, 11,400 pounds; center of gravity at 25.8 percent M.A.C.

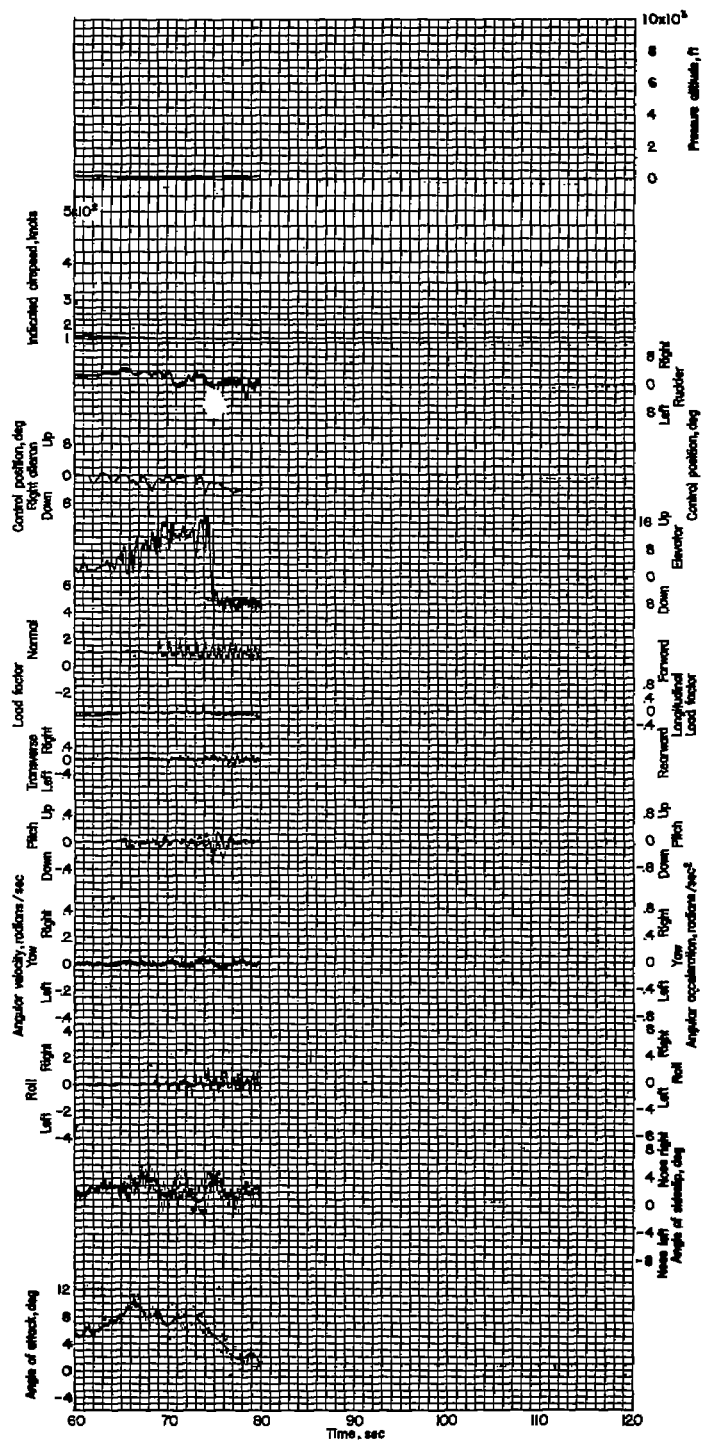




(a)



Figure 289.- Landing. Pilot A; airplane weight, 11,835 pounds; center of gravity at 26.6 percent M.A.C.



(b)



Figure 289.- Concluded.

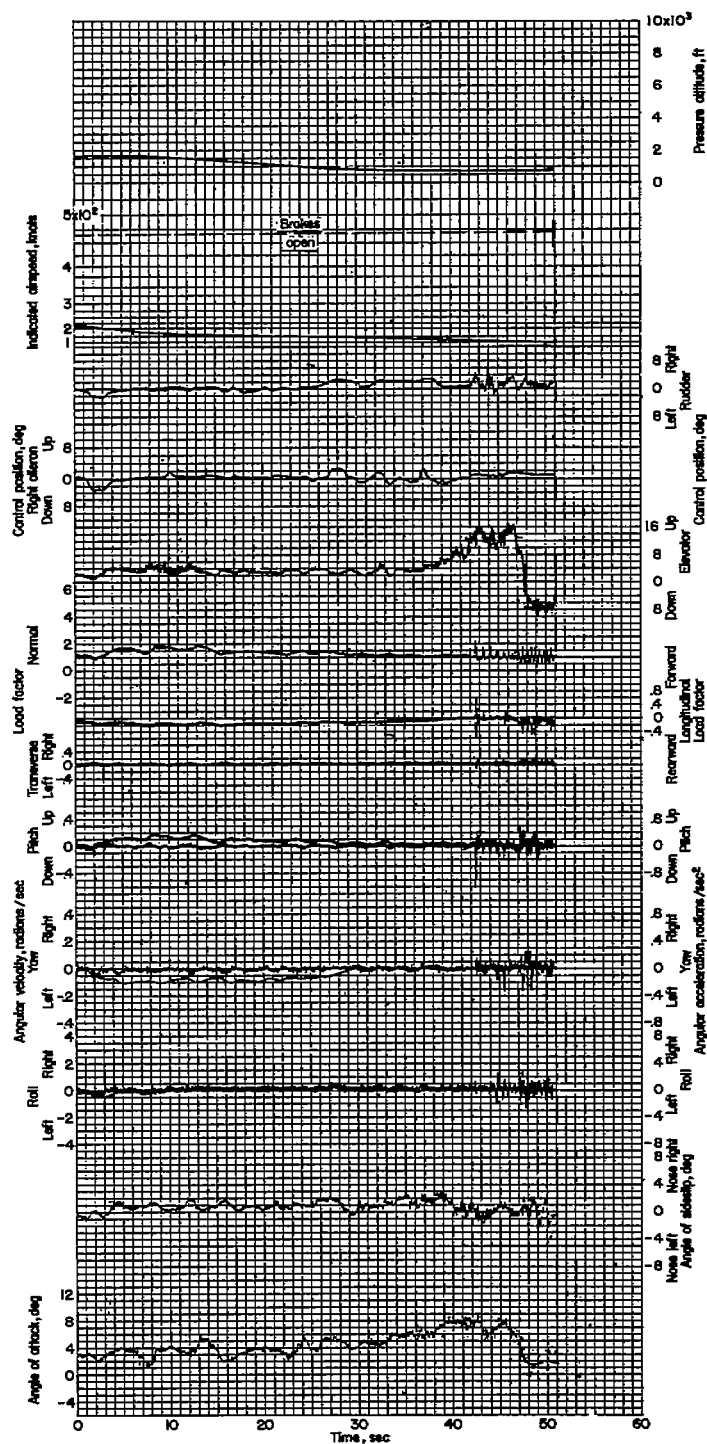


Figure 290.- Landing. Pilot A wearing anti-gravity suit; airplane weight, 11,610 pounds; center of gravity at 26.1 percent M.A.C.

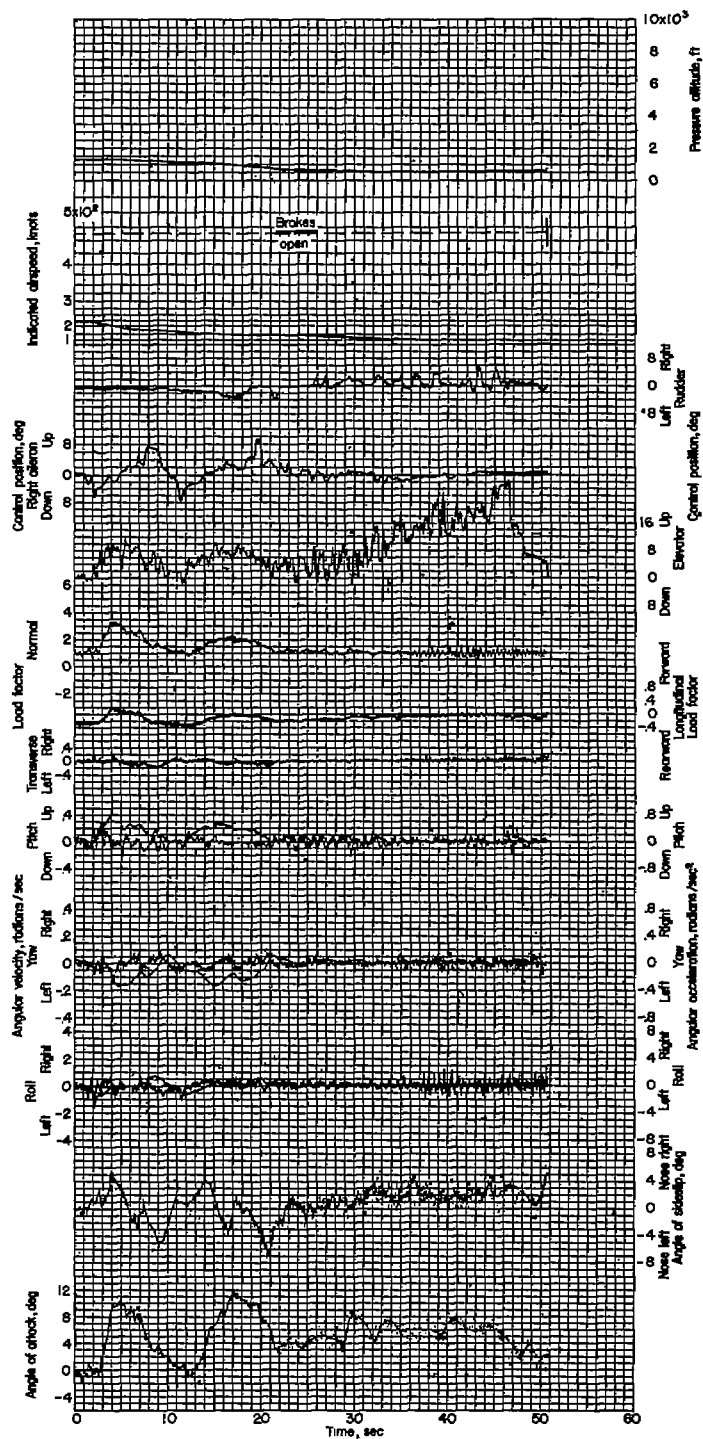


Figure 291.- Landing. Pilot B; airplane weight, 11,610 pounds; center of gravity at 26.1 percent M.A.C.



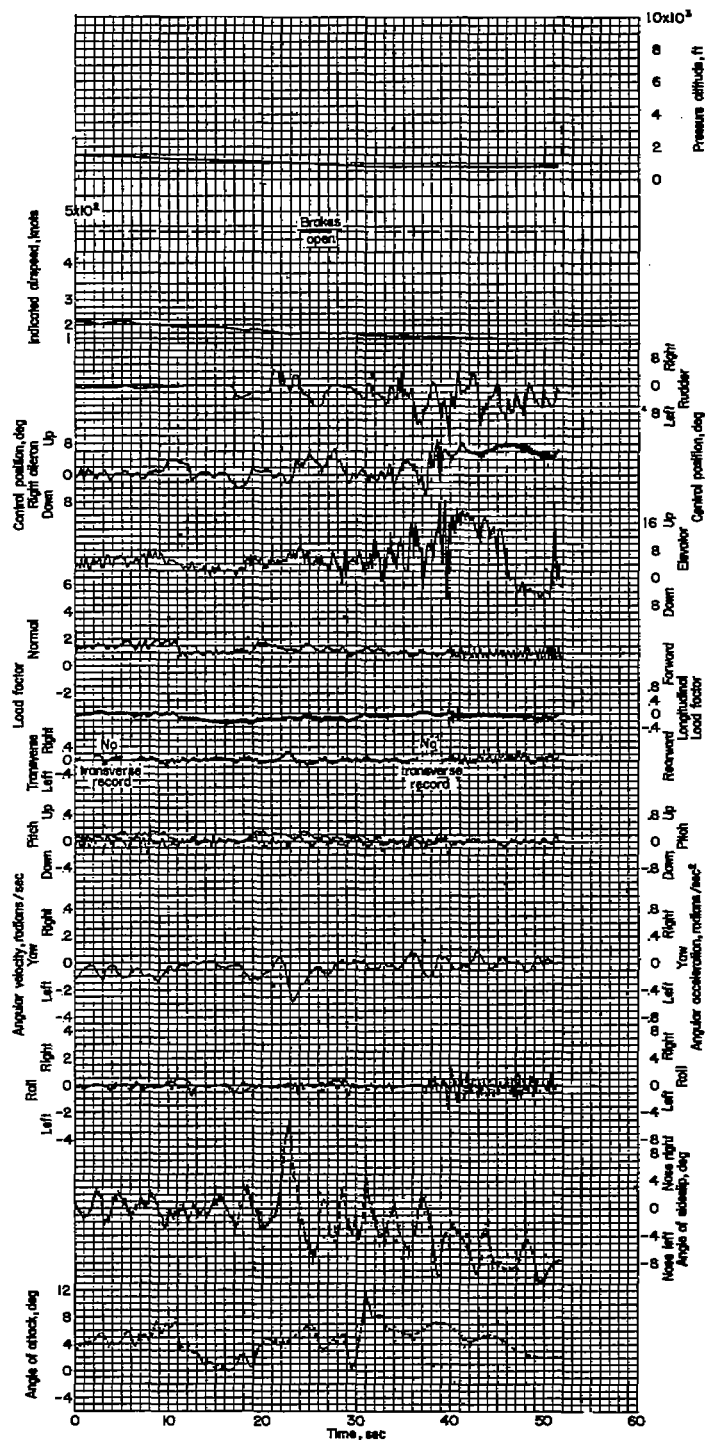


Figure 292.- Landing. Pilot B with radar observer; airplane weight, 11,860 pounds; center of gravity at 25.3 percent M.A.C.

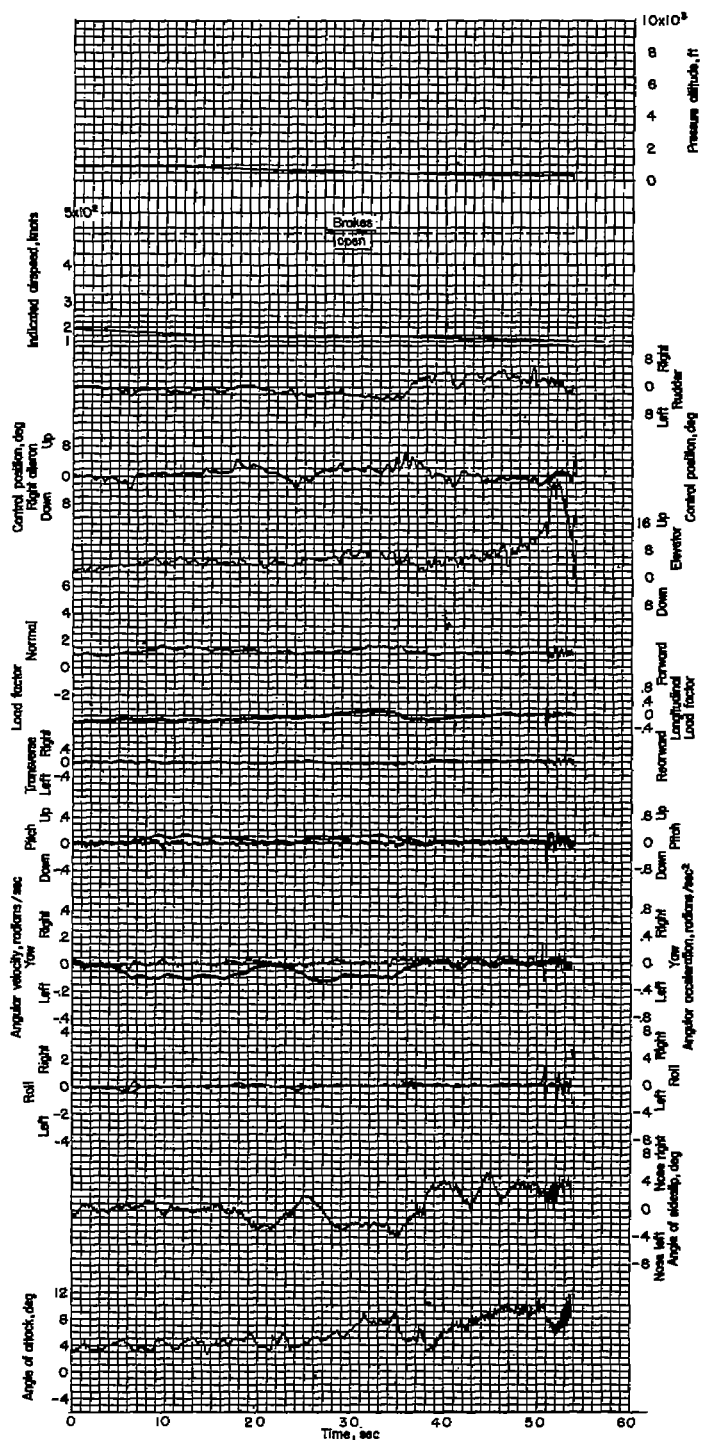
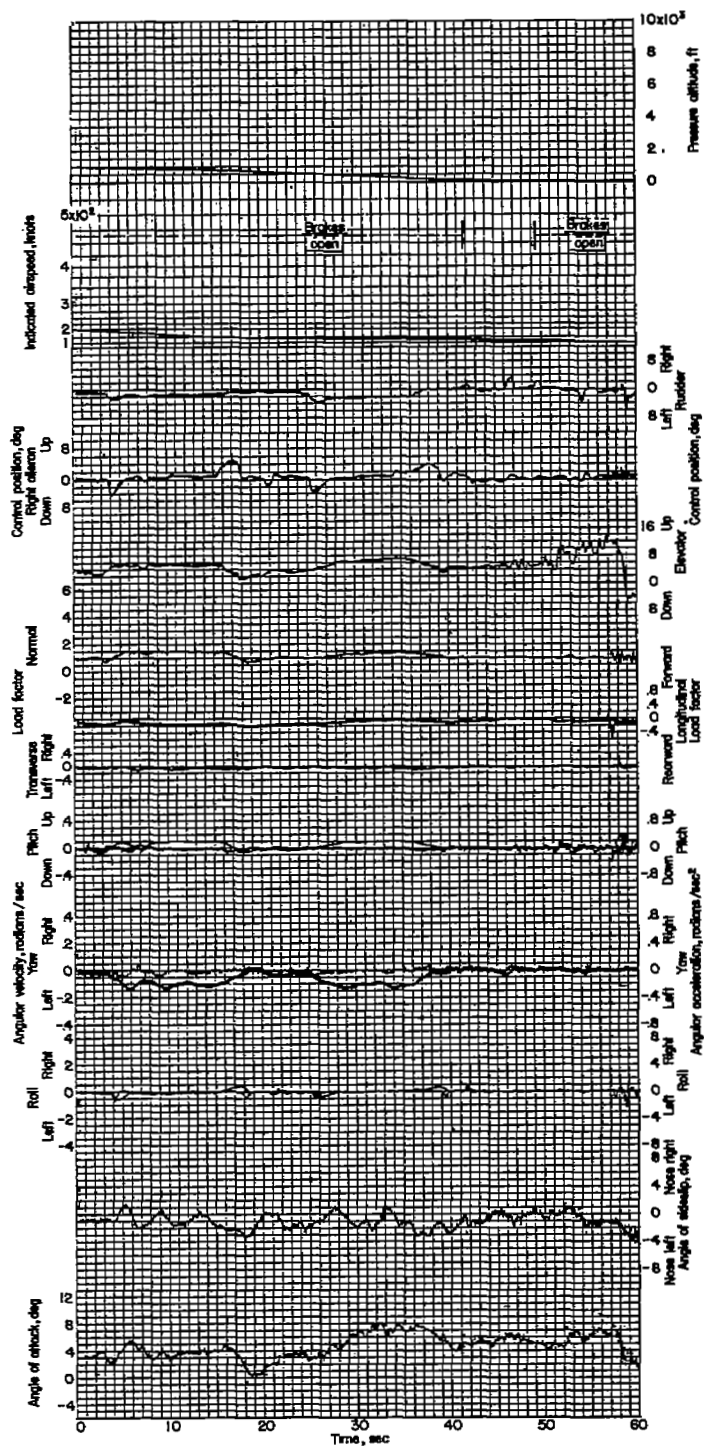


Figure 293.- Landing. Pilot C with radar observer; airplane weight, 11,795 pounds; center of gravity at 25.1 percent M.A.C.



(a)

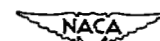
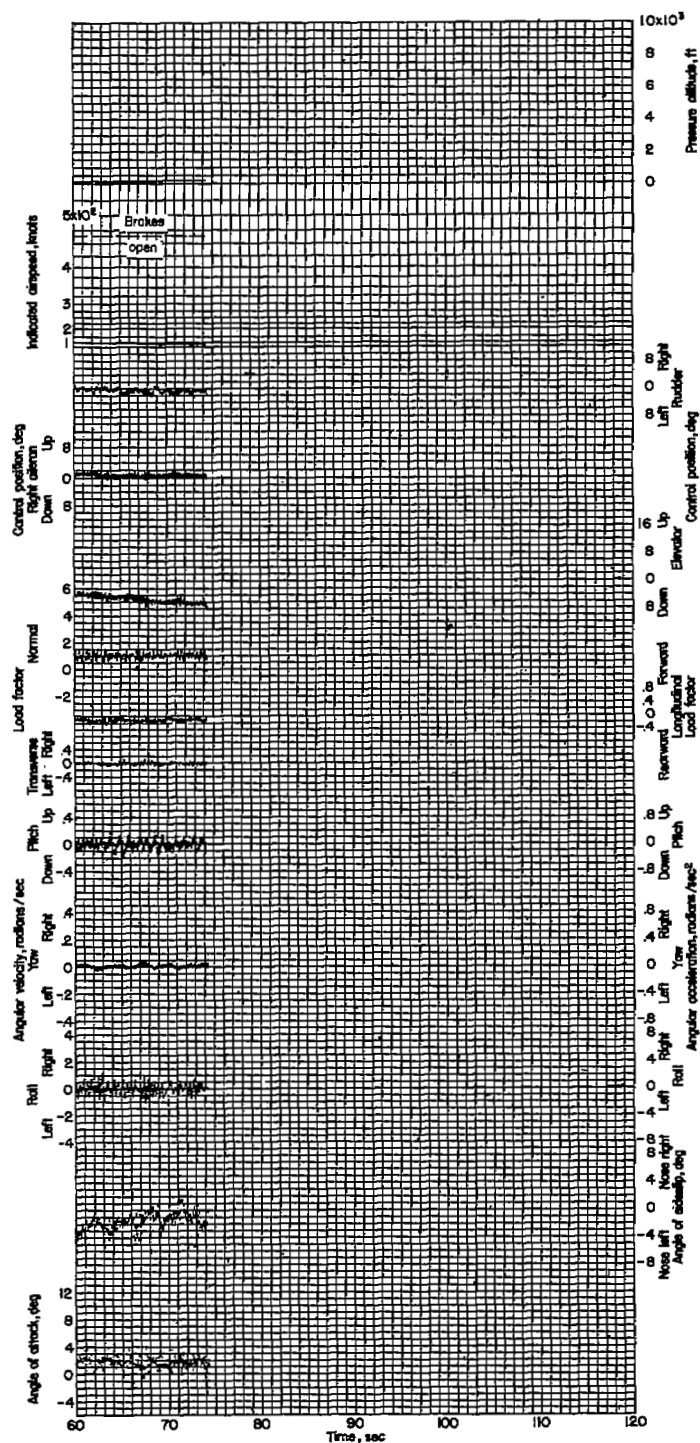


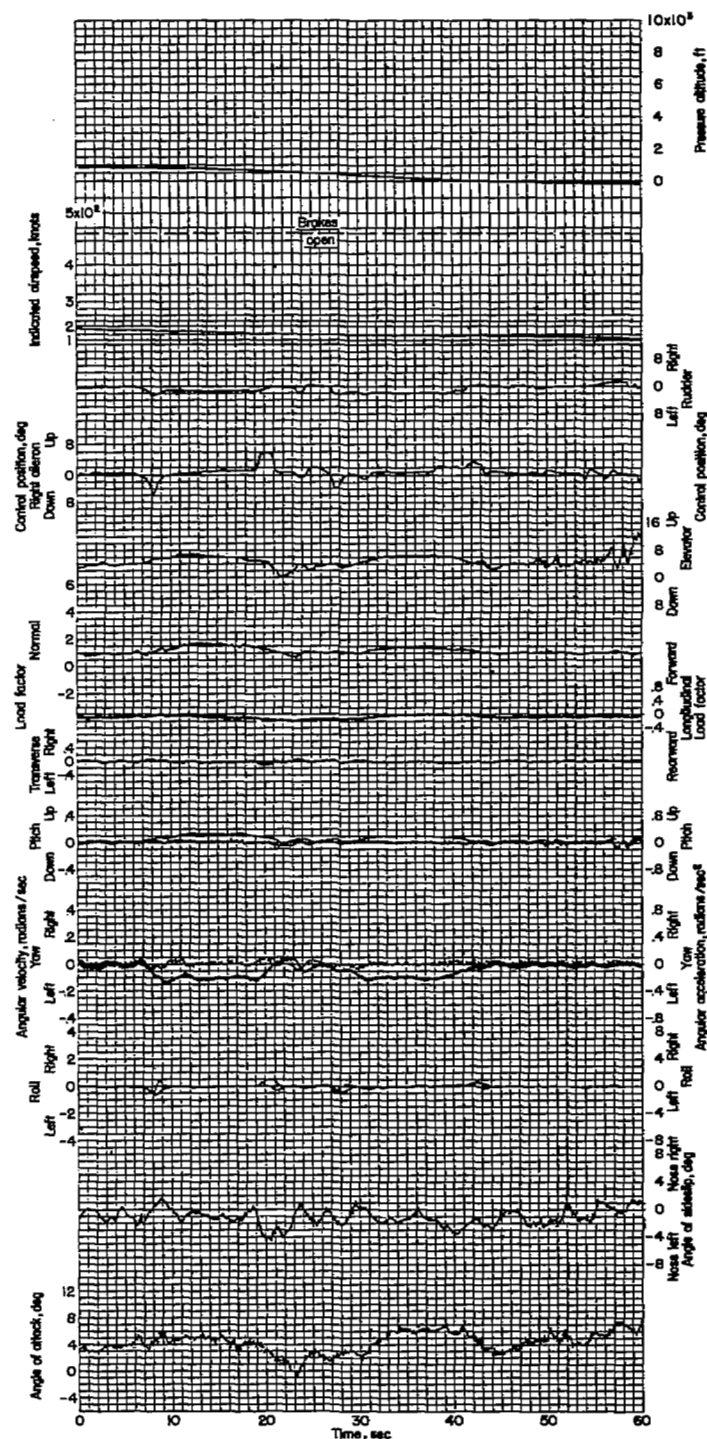
Figure 294.- Landing. Pilot D with radar observer; airplane weight, 11,750 pounds; center of gravity at 25.0 percent M.A.C.



(b)



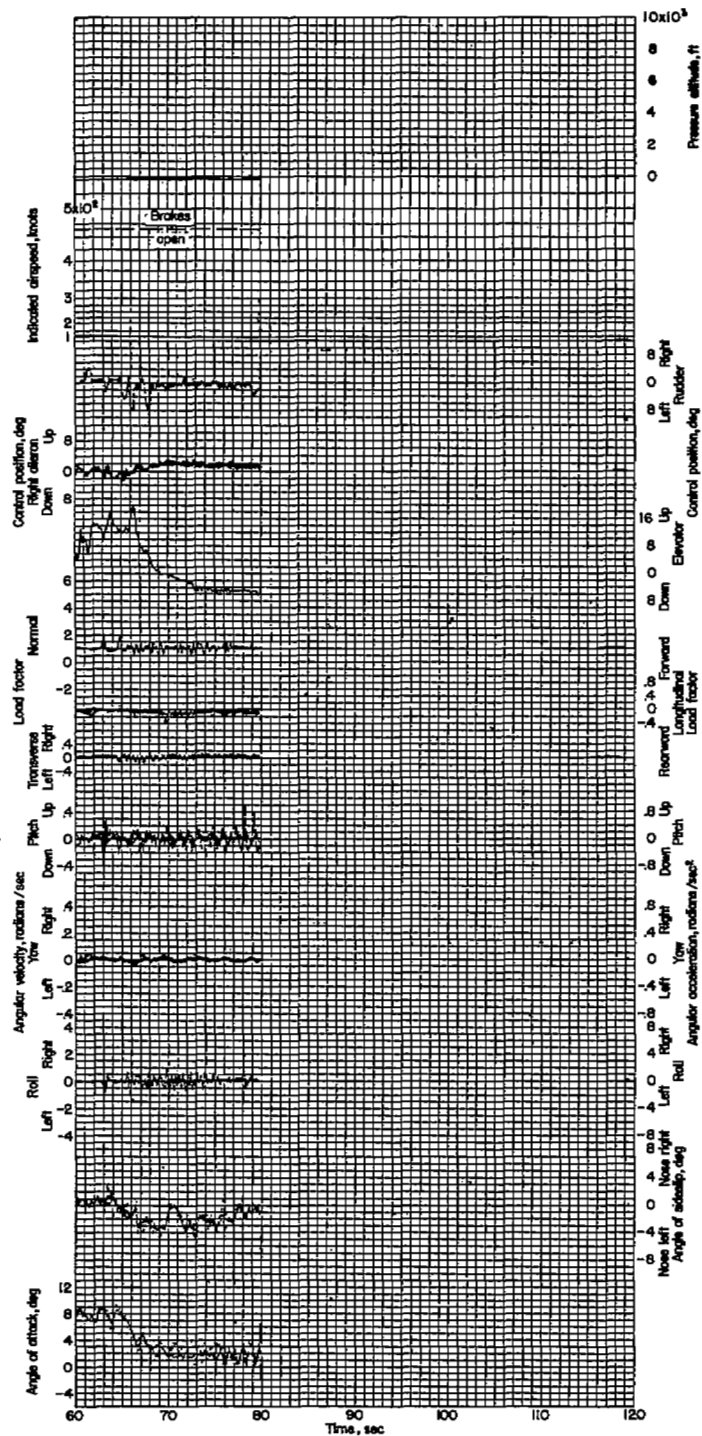
Figure 294.- Concluded.



(a)

NACA

Figure 295.- Landing. Pilot D with radar observer; airplane weight, 12,025 pounds; center of gravity at 25.6 percent M.A.C.



(b)



Figure 295.- Concluded.

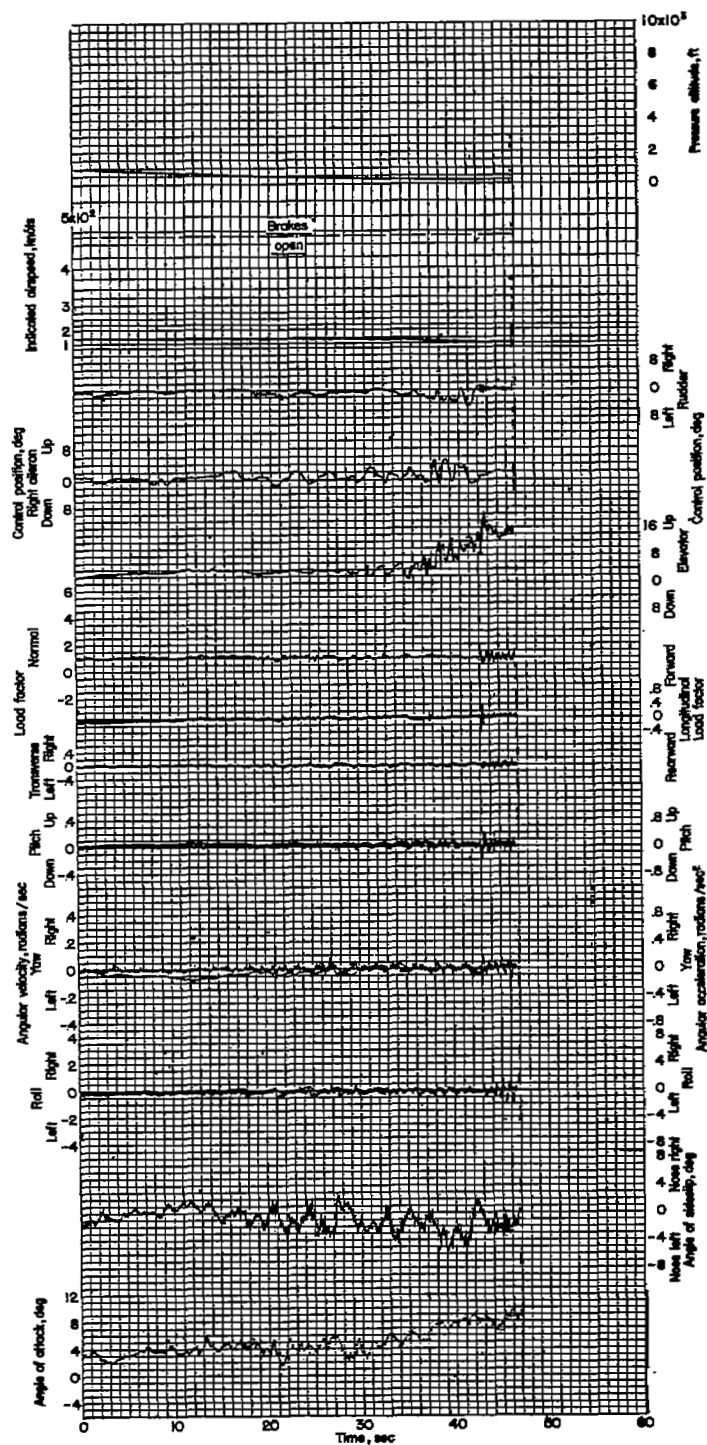
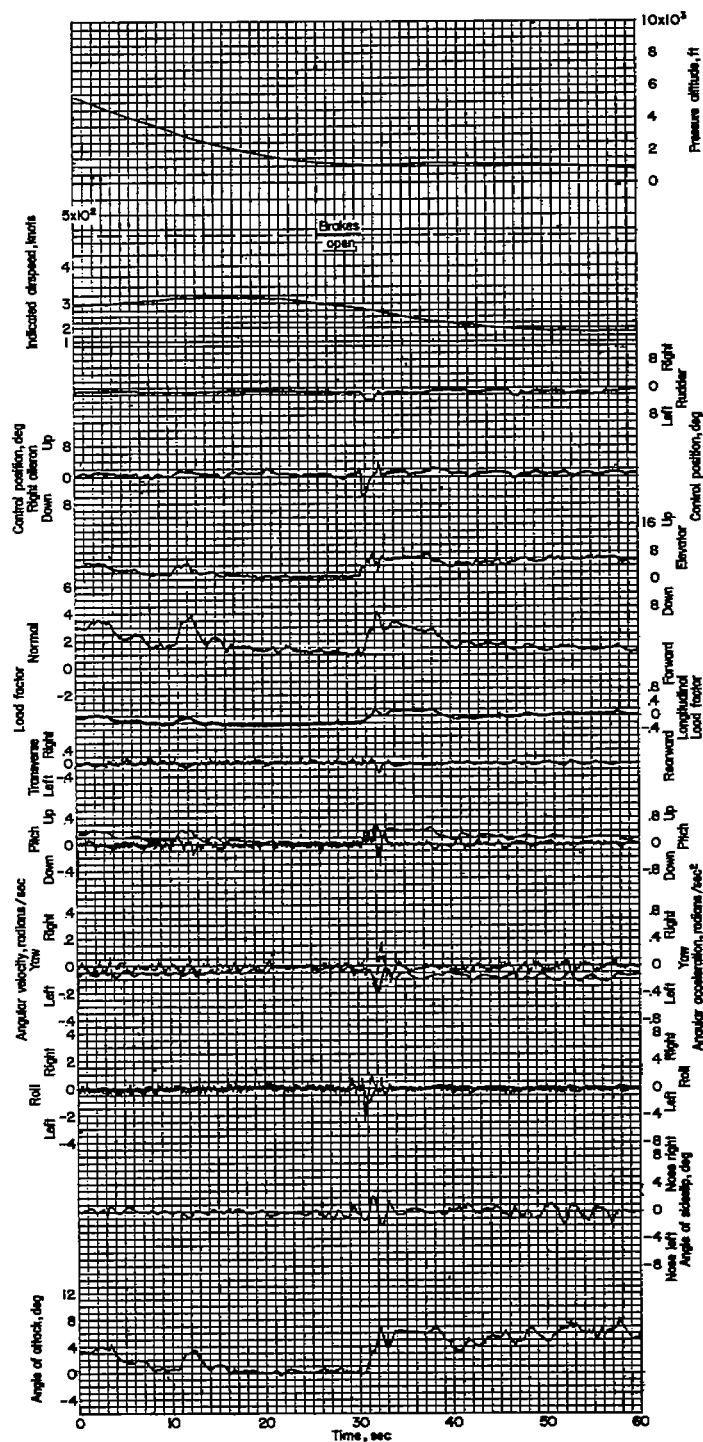


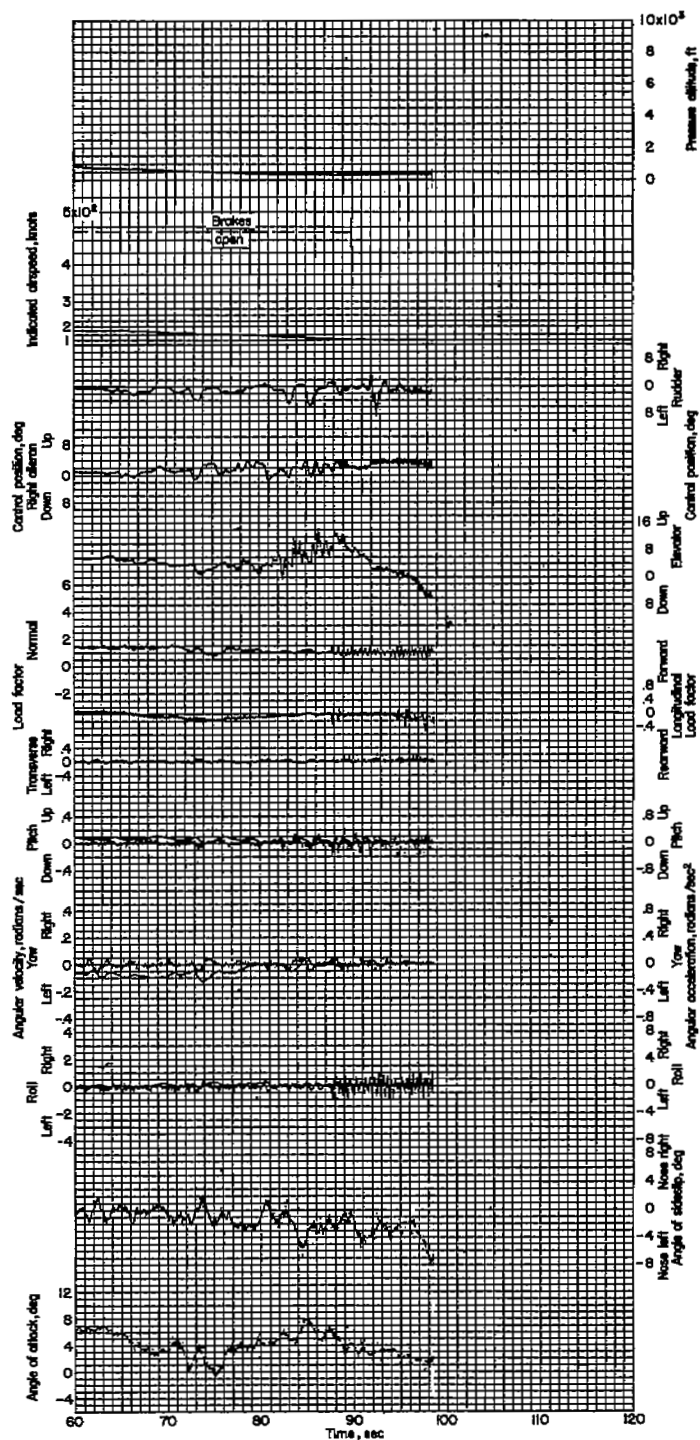
Figure 296.- Landing. Pilot E wearing anti-gravity suit; airplane weight, 11,450 pounds; center of gravity at 25.8 percent M.A.C.



(a)



Figure 298.- Landing. Pilot F wearing anti-gravity suit; airplane weight, 11,550 pounds; center of gravity at 26.0 percent M.A.C.



(b)



Figure 298.- Concluded.

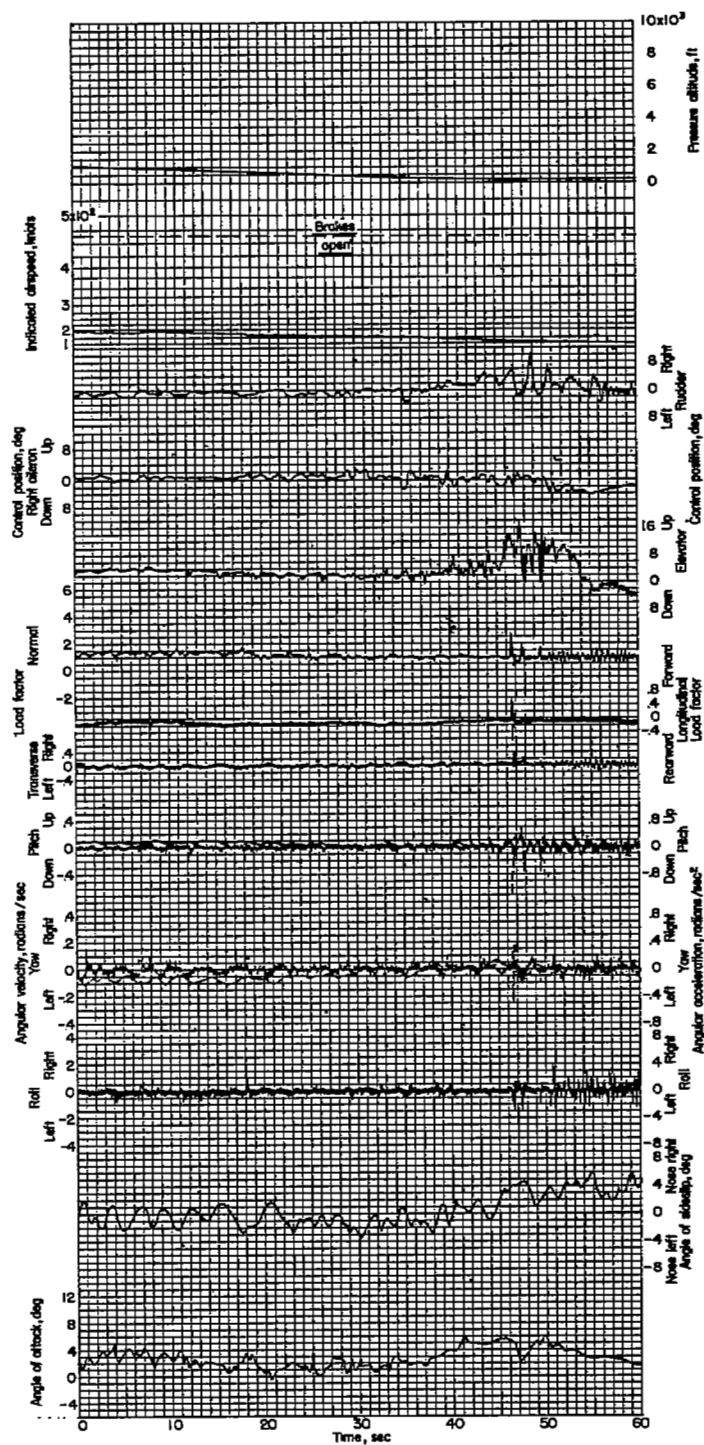


Figure 299.- Landing at night. Pilot F wearing anti-gravity suit and with radar observer; airplane weight, 11,900 pounds; center of gravity at 25.3 percent M.A.C.

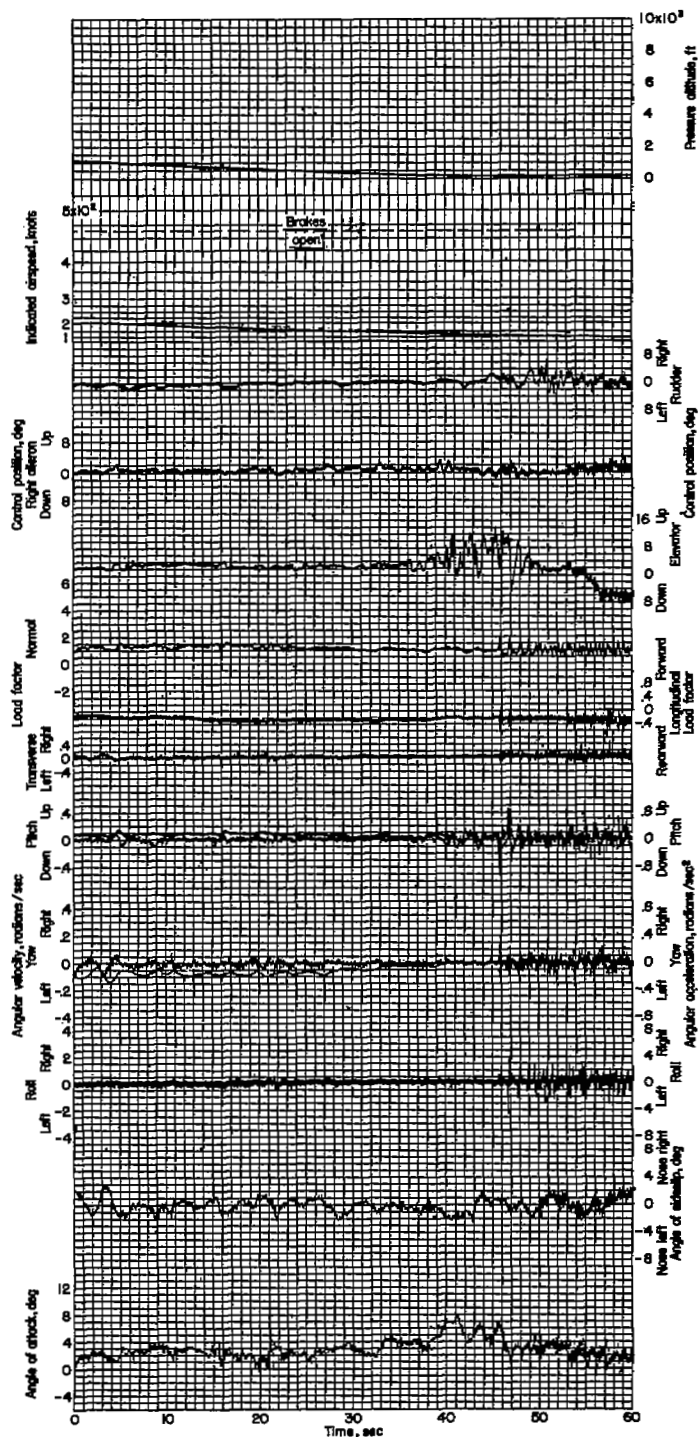


Figure 300.- Landing. Pilot F wearing anti-gravity suit and with radar observer; airplane weight, 12,035 pounds; center of gravity at 25.6 percent M.A.C.

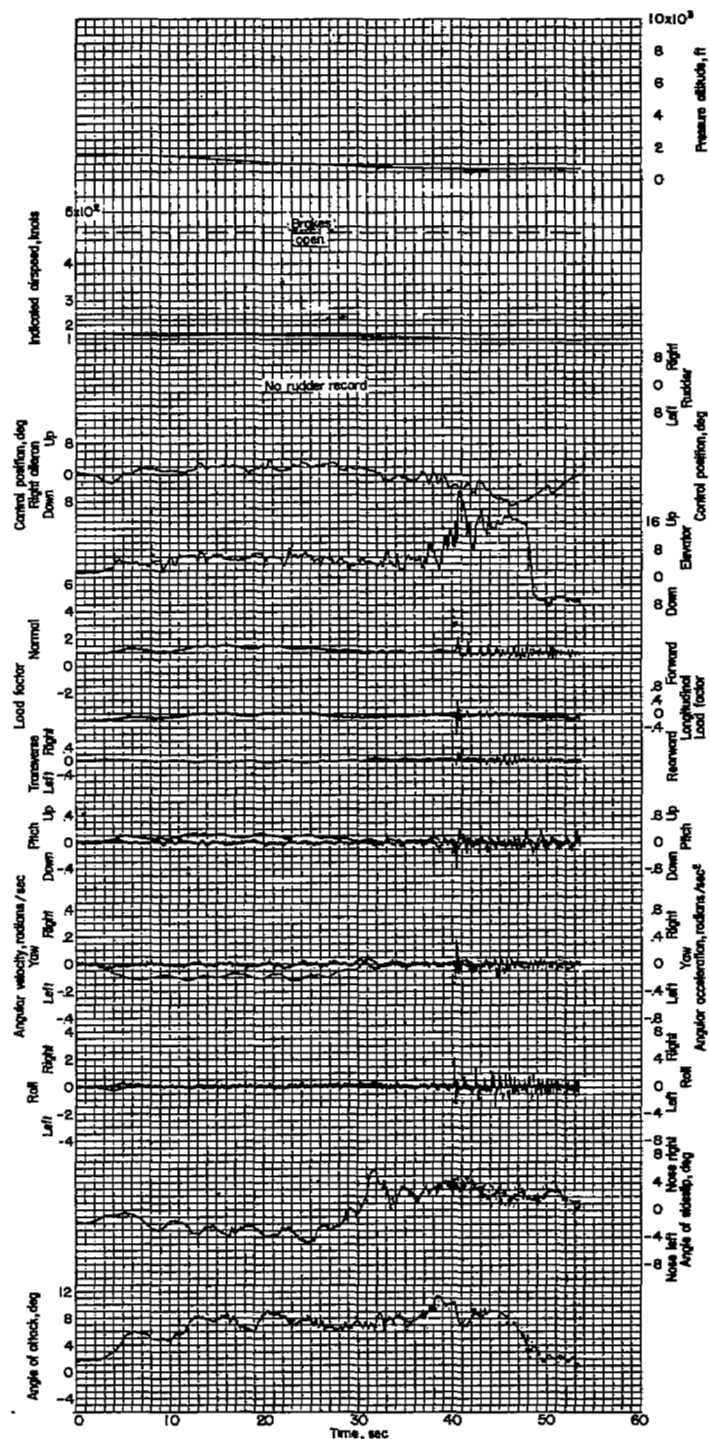


Figure 301.- Landing. Pilot G; airplane weight, 11,500 pounds; center of gravity at 25.9 percent M.A.C.

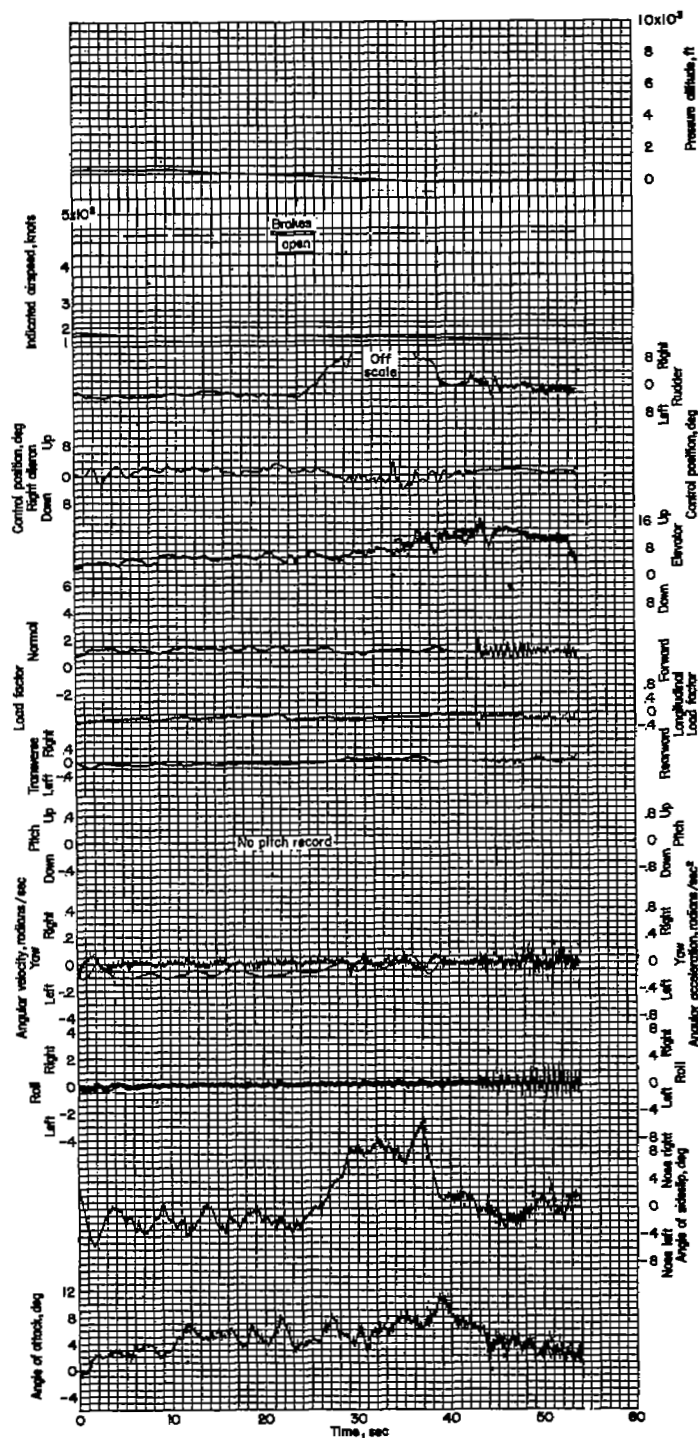
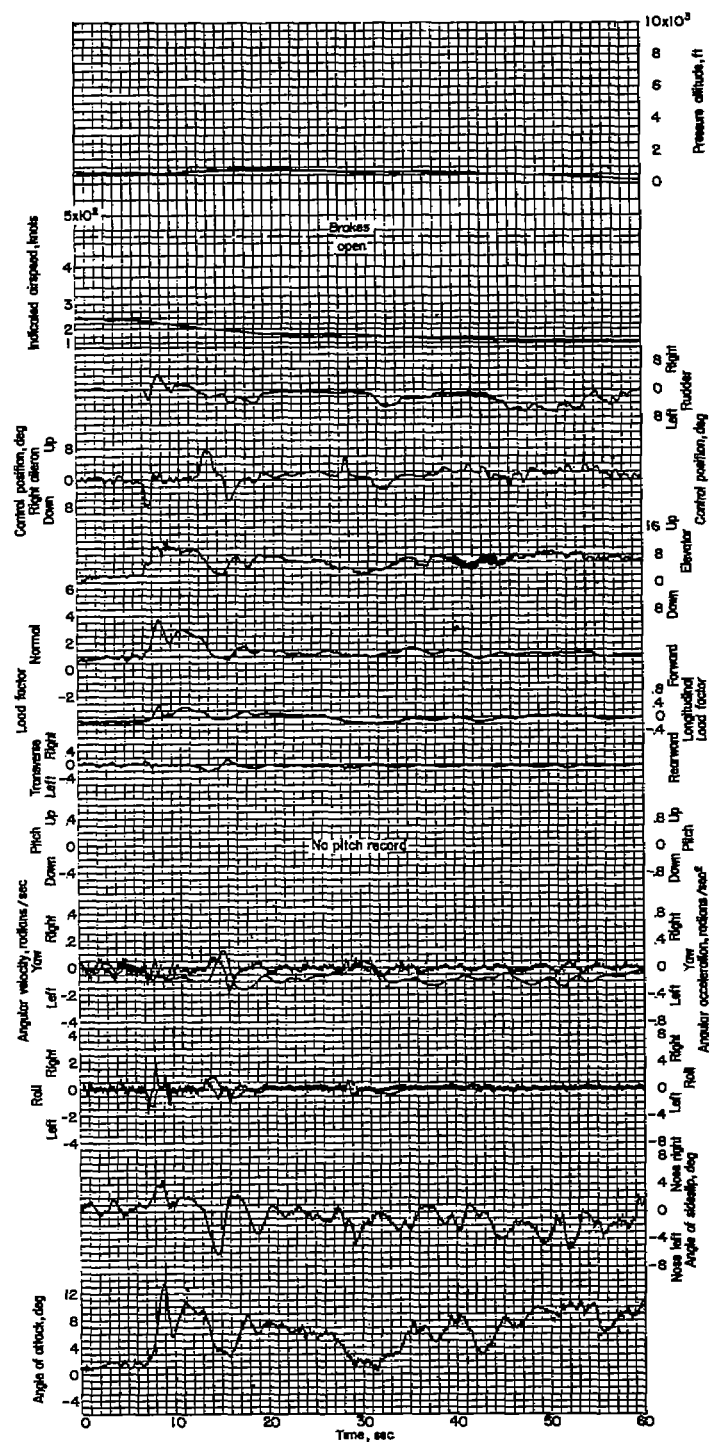


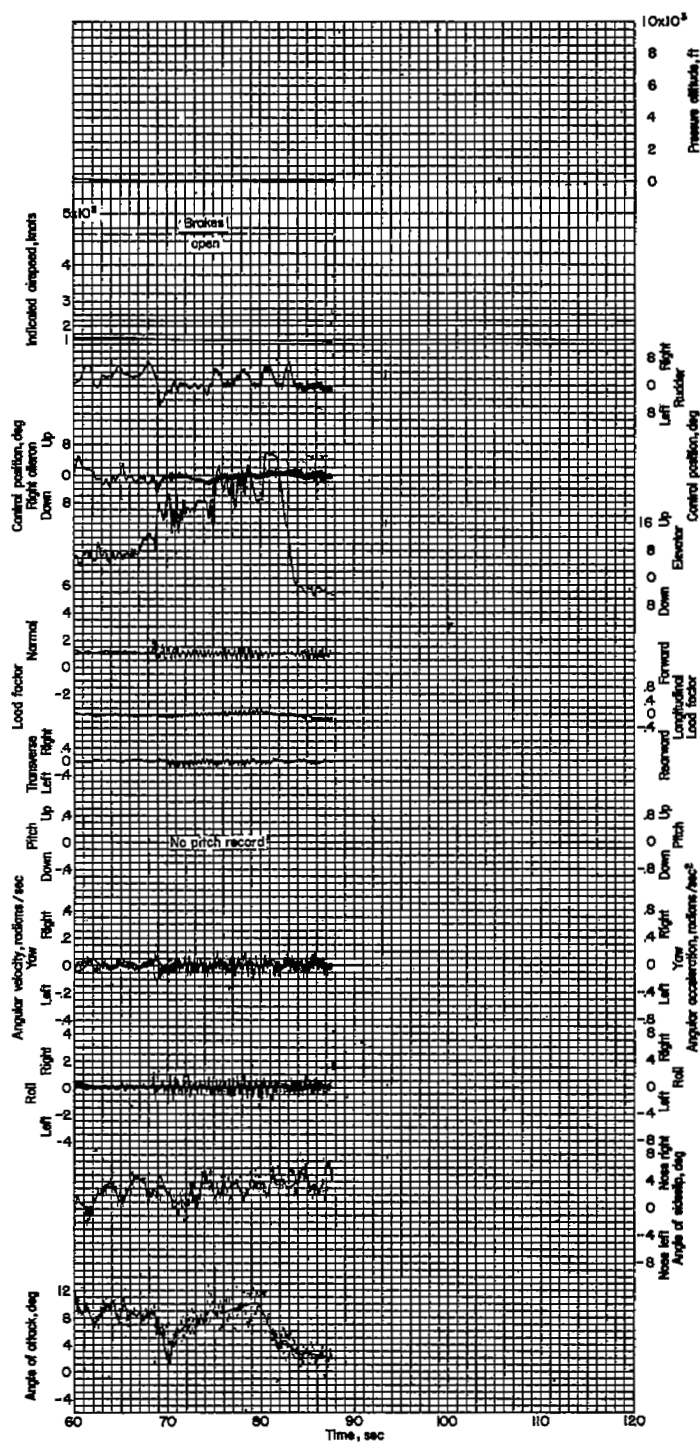
Figure 302.- Landing. Pilot G with radar observer; airplane weight, 12,080 pounds; center of gravity at 25.7 percent M.A.C.



(a)



Figure 303.- Landing. Pilot G with radar observer; airplane weight, 12,065 pounds; center of gravity at 25.7 percent M.A.C.



(b)

Figure 303.- Concluded.



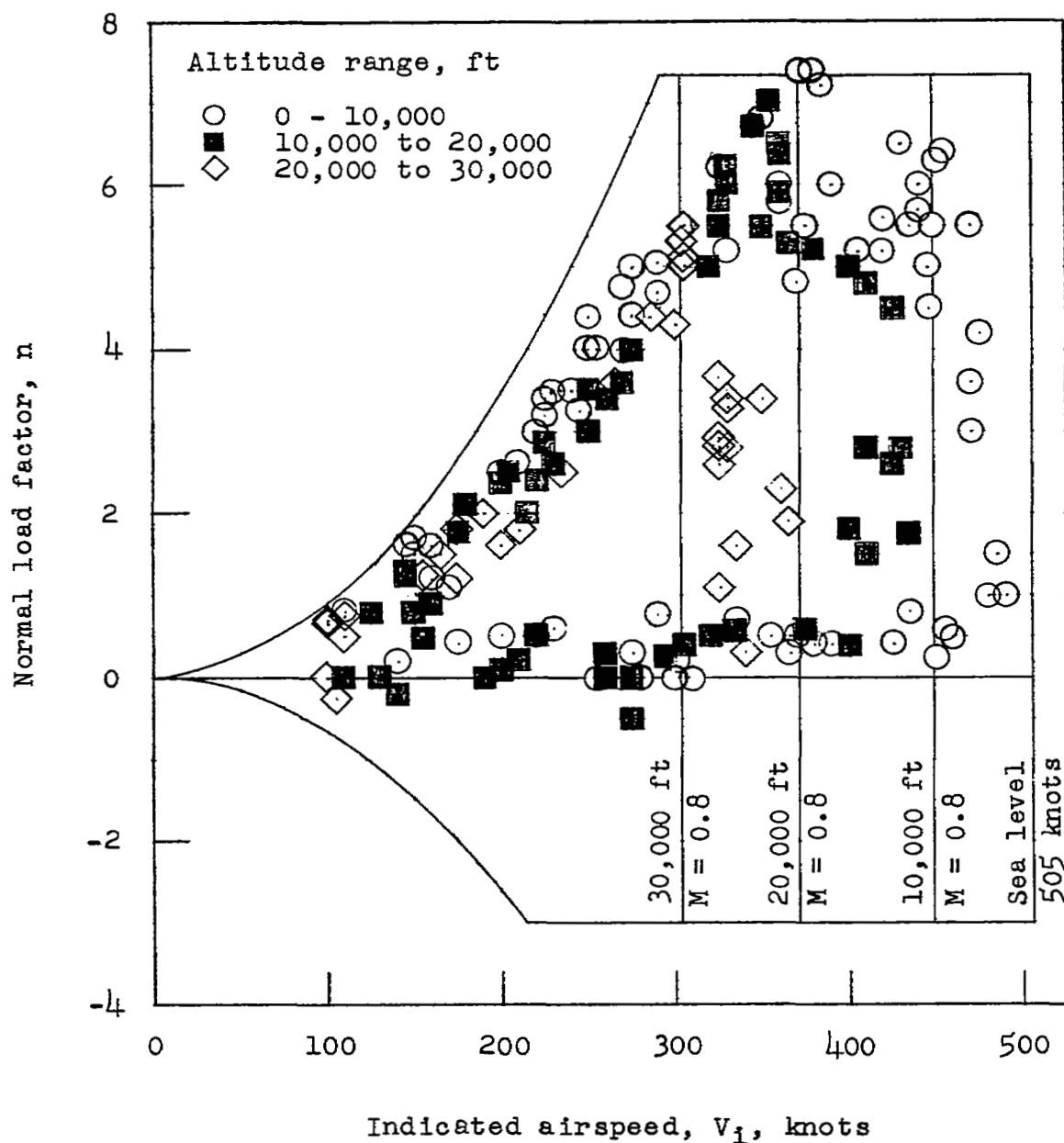


Figure 304.- Comparison of measured normal load factors with the operational V-n diagram. Limit envelopes are for an average in-flight gross weight of 12,238 pounds.

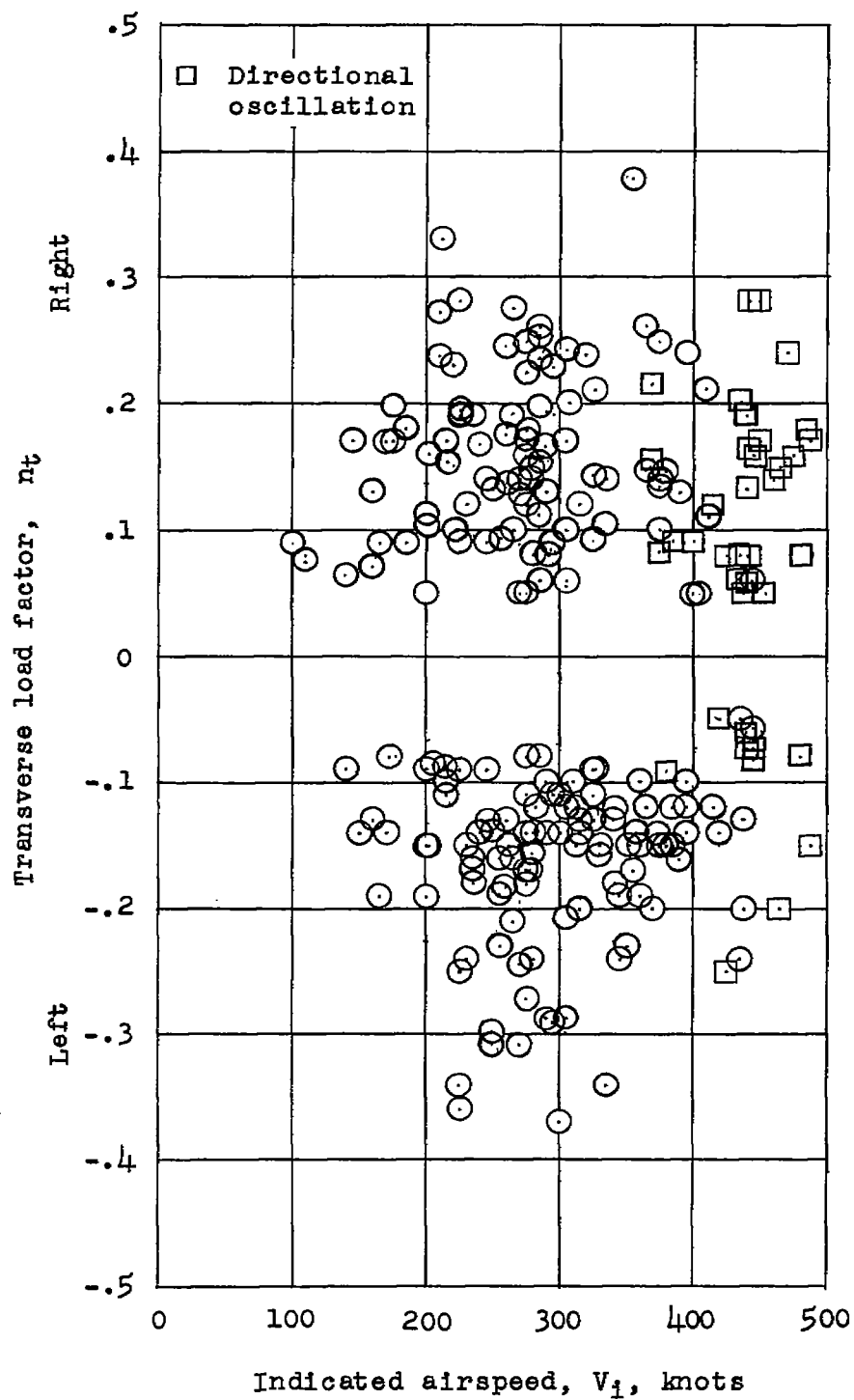


Figure 305.- Variation of maximum corrected transverse load factors with indicated airspeed.

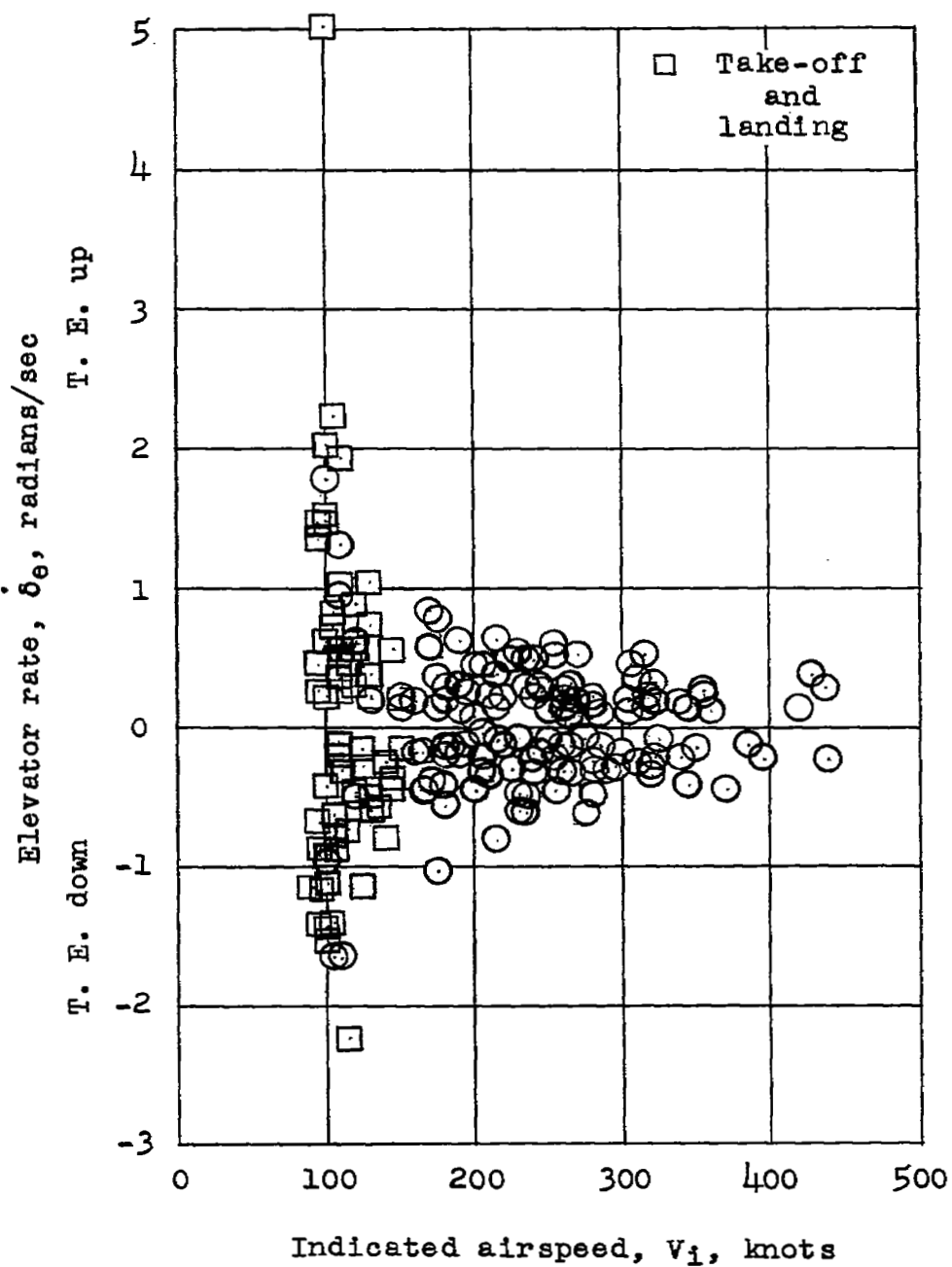


Figure 306.- Variation of maximum elevator rates with indicated airspeed.

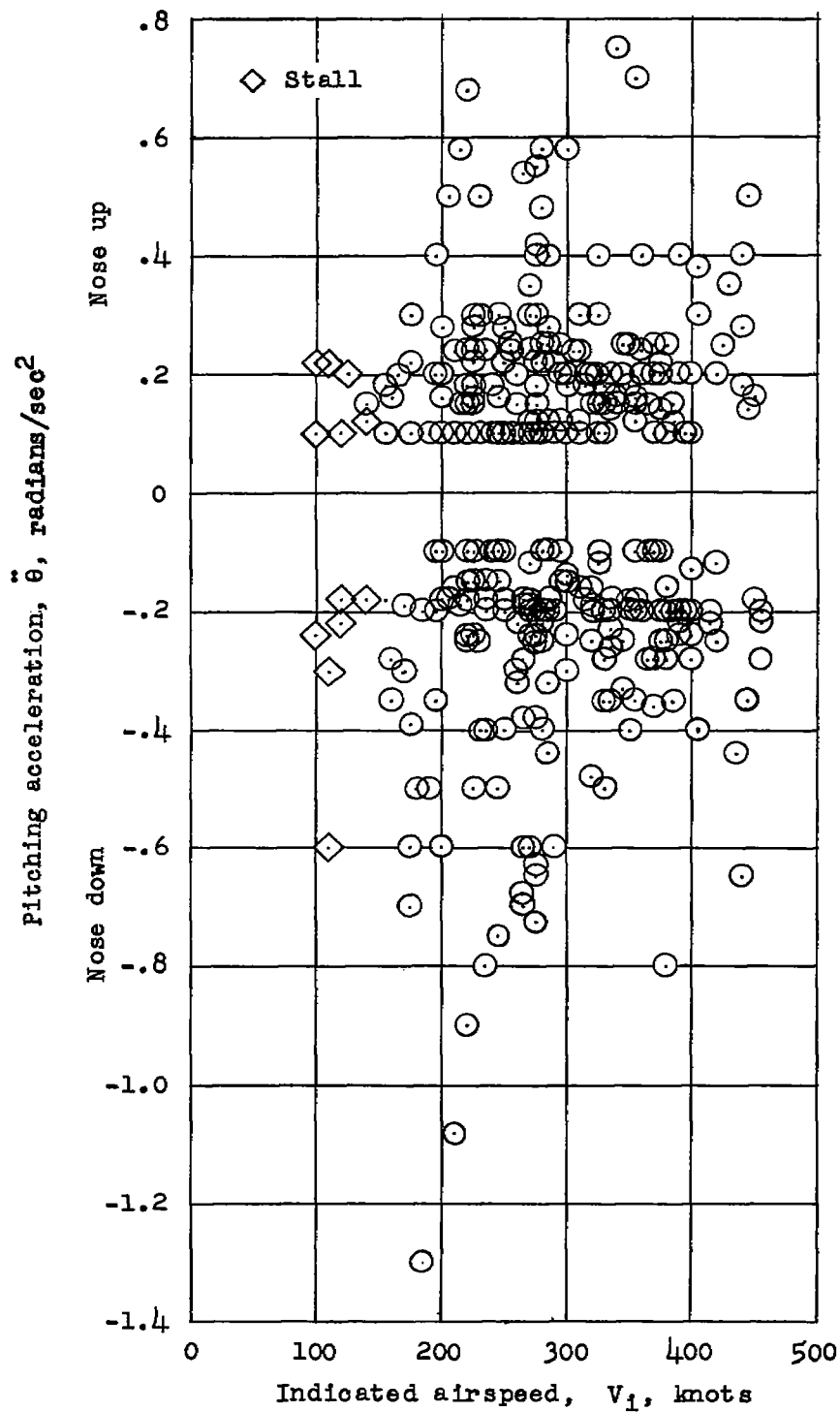


Figure 307.- Variation of maximum pitching accelerations with indicated airspeed.



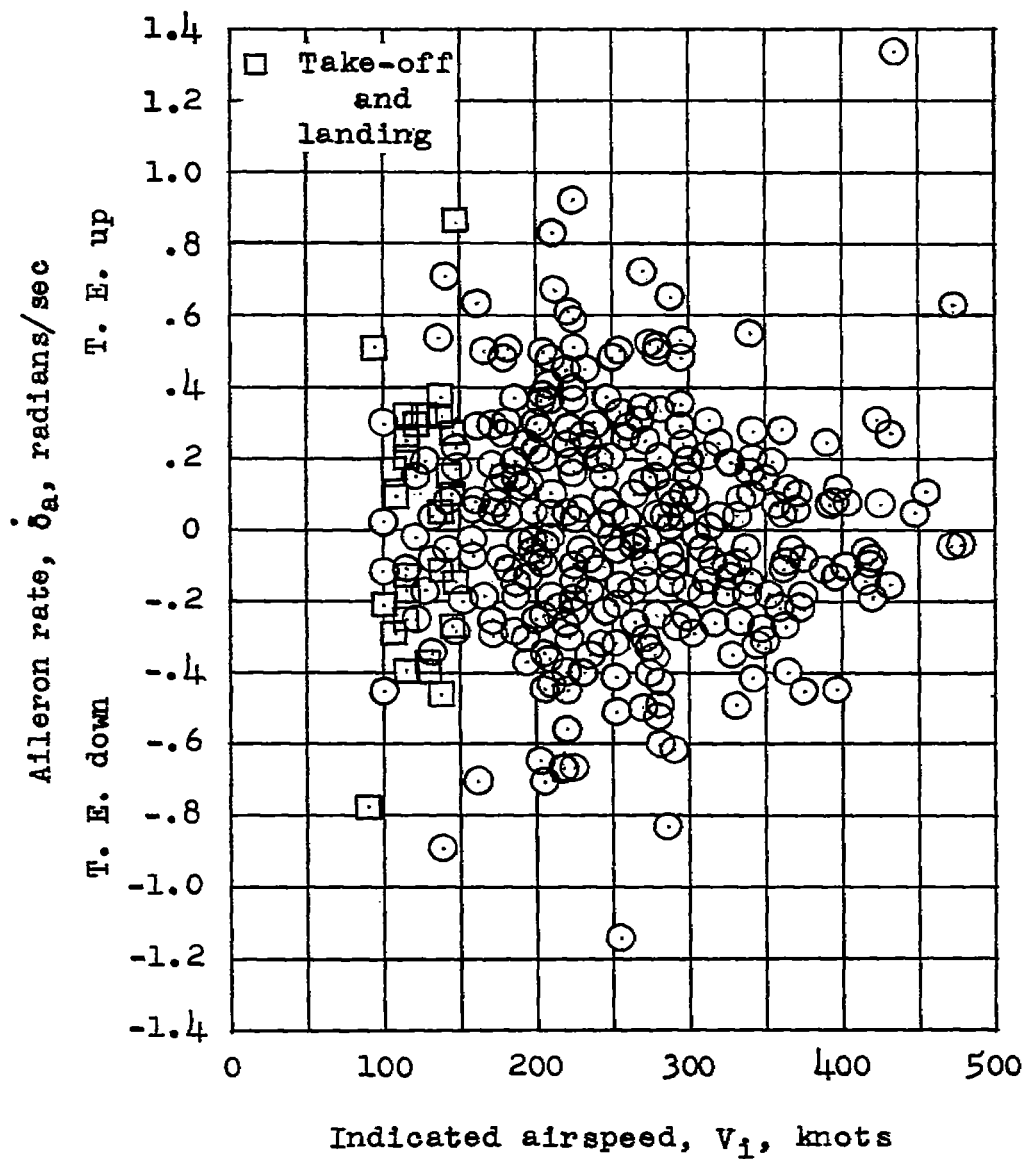


Figure 308.- Variation of maximum right aileron rates with indicated airspeed.



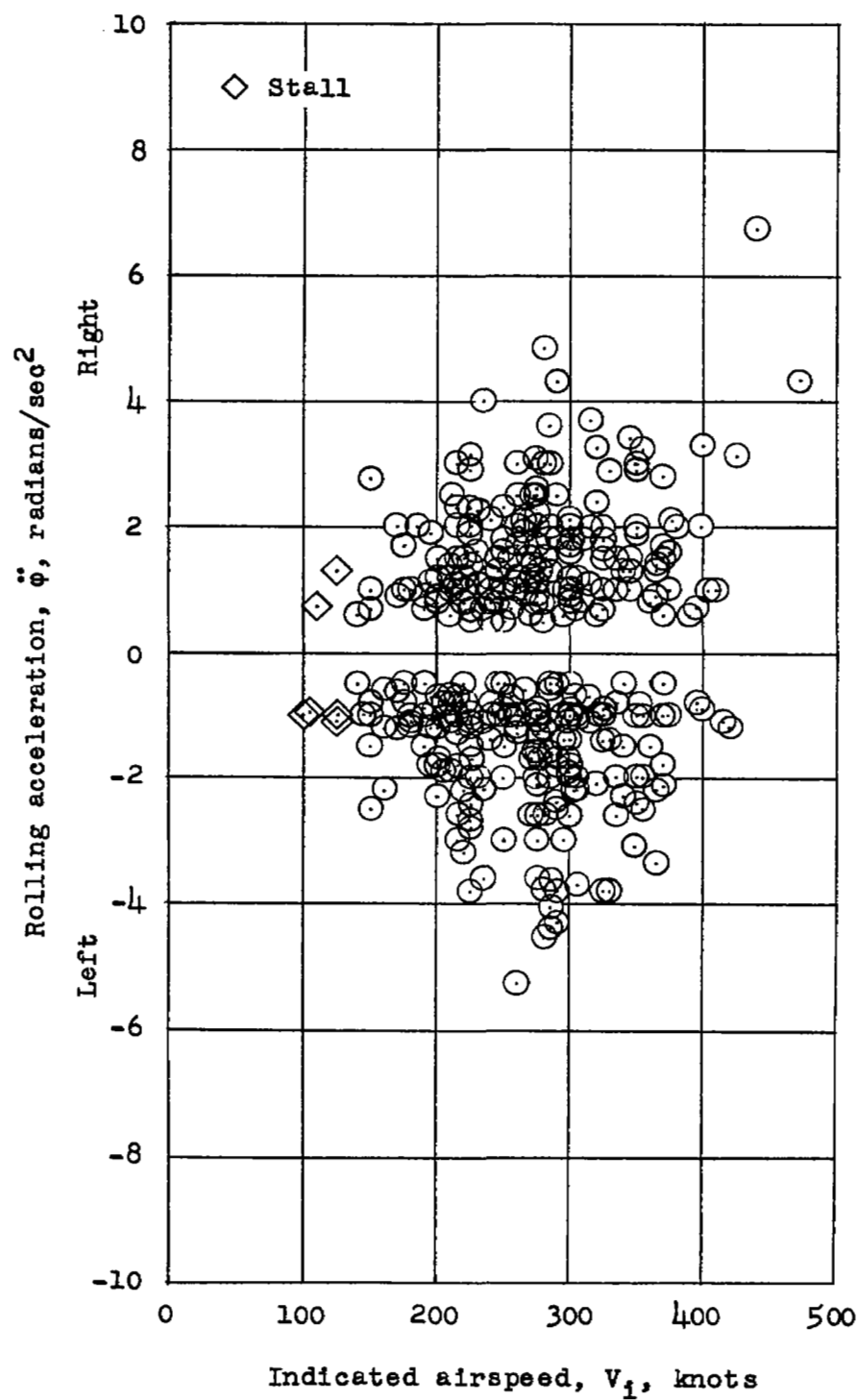


Figure 309.- Variation of maximum rolling accelerations with indicated airspeed.

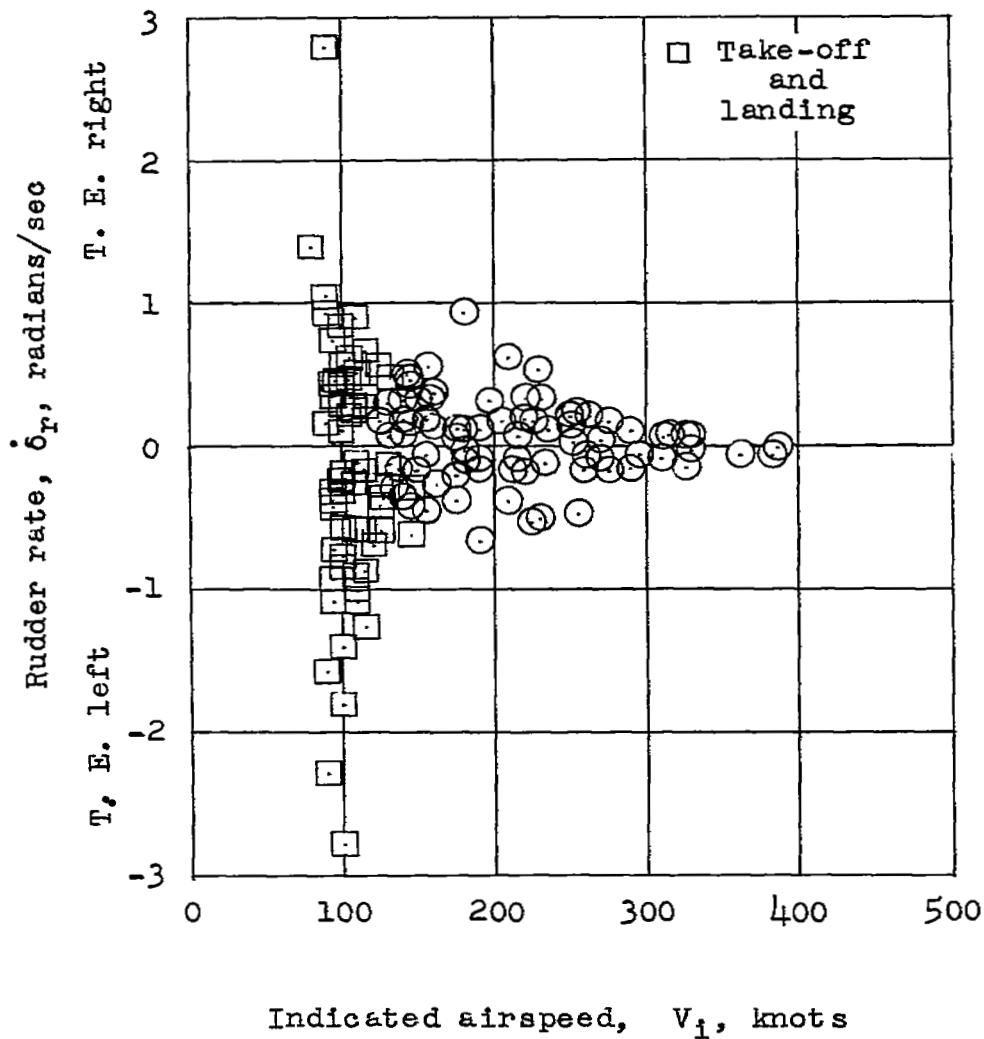


Figure 310.- Variation of maximum rudder rates with indicated airspeed.

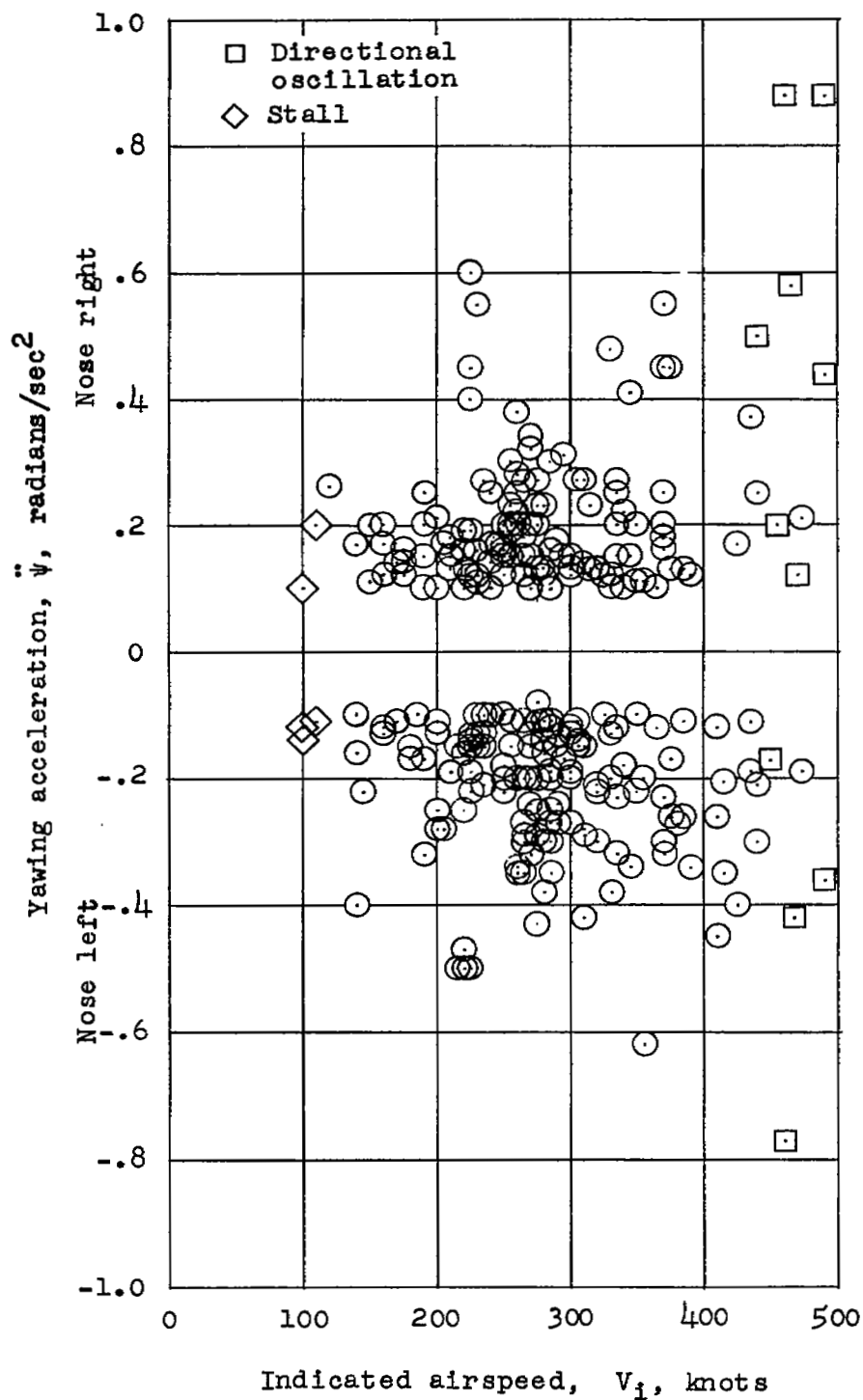


Figure 311.- Variation of maximum yawing accelerations with indicated airspeed.

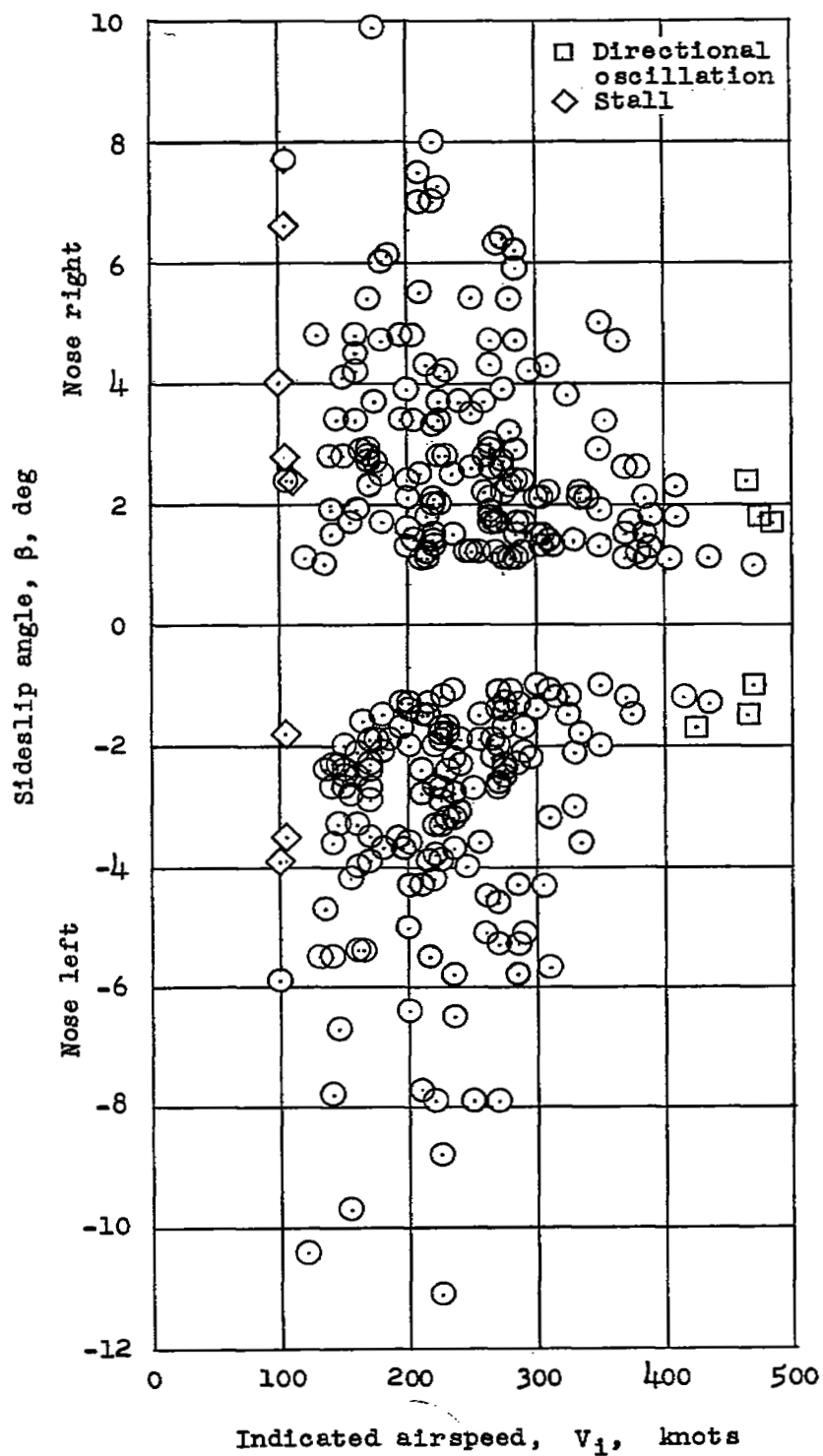


Figure 312.- Variation of maximum sideslip angles with indicated airspeed.

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